This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

The Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY

[redacted]

TRANSACTIONS

OF THE

MANCHESTER

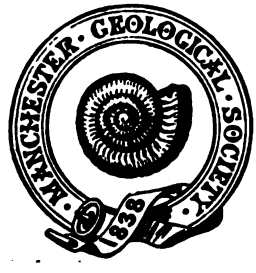
GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME EIGHTEENTH,

PARTS I.—XX. 1884–85–86.



MANCHESTER:

SOLD AT THE ROOMS OF THE SOCIETY,

36, GEORGE STREET, MANCHESTER.

MDCCCLXXXVI.

212964

*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

LIBRARY

CONTENTS OF VOL. XVIII.

PAGE

Annual Meeting, 7th October, 1884 1

,, ,, 6th October, 1885 237

Report of the Council for Session 1883-84 1

,, ,, ,, 1884-85.. 237

Treasurer's Balance Sheet for Session 1883-84 5

,, ,, ,, 1884-85.. 241

List of Papers, &c., read during the Sessions .. .... 8 & 244

Officers and Council for 1883-84 and 1884-85 .. .. .. 7 & 243

Past Presidents of the Society.. .. ..10 & 246

List of Members .. ..11 & 247

Presentations to the Library, 1884-85 256

Additions to the Library, 1884, 1885-86..45, 121, 175, 207, 325, 491

Societies with whom Transactions are Exchanged .. ..25 & 263

Ordinary Meeting, November, 1884 29

President's Address 29

Coal Dust in connection with Colliery Explosions.. 34

Discussion on the Mineral Veins of the Lake District 38

Ordinary Meeting, December, 1884 45

Paper. Professor W. B. Dawkins, F.R.S. On some Deposits of Apatite near Ottawa, Canada 47

Paper. C. E. De Rance, F.G.S. On the Occurrence of Brine in the Coal Measures.. 61

Paper. J. S. Martin, F.G.S. On an Automatic Safety Lamp.. 82

PAGE.

Ordinary Meeting, January, 1885 85

Paper. J. S. Burrows, M.E. On an Automatic Safety Lamp 85

Paper. Arnold Budenberg. Description of Steel Tube Gauge for High Pressures 96

Extra Meeting at Owens College, January 13th, 1885 101

Address. Professor W. B. Dawkins, M.A., F.R.S. The Carboniferous Flora 101

Address. Professor W. C. Williamson, LL.D., F.R.S. 113

Ordinary Meeting, February, 1885 121

Paper. G. H. Kinahan, M.R.I.A. On a Possible Genesis of the Canadian Apatite 123

Paper. Mr. G. A. Kinahan. On the Apatite Deposits near Ottawa 132

Discussion 135

Discussion on Mr. De Rance's Paper 140

Ordinary Meeting, March, 1885 149

Paper. Mr. John S. Burrows. On Accidents in Mines and their Prevention 150

Discussion 162

Excursion to Sheffield and Aldwarke 169

Ordinary Meeting, April, 1885 175

Discussion on Mr. J. S. Burrows' Paper on Accidents in Mines 176

Safety Lamp Experiments at Aldwarke 186

Paper. Mark Stirrup, F.G.S. On Coal and Coal Plants .. 189

Ordinary Meeting, May, 1885 197

Discussion on Accidents in Mines 197

Ordinary Meeting, June, 1885 207

Paper. R. T. Burnett, F.G.S. The Age of the Rocks of St. David's 209

Discussion 228

PAGE.

Discussion on Mr. Stirrup's Paper on Coal and Coal Plants.. 232

Paper. The Fossil Insects of the Primary Group of Rocks. CHARLES BRONGNIART, F.E.S. (translated by MARK STIRRUP) 269

Discussion.. 289

Footprints in Sandstone Flag. H. M. ORMEROD, F.G.S. 293

Paper. G. C. GREENWELL, F.G.S. Geology of the Island of Jersey 295

Discussion.. 300

Paper. W. E. GARFORTH, M.E. On Working Coal by Long-wall 302

Discussion.. 322

Ordinary Meeting, December, 1885 325

Discussion. M. Charles Brongniart's Paper on Fossil Insects. 328

Paper. MARK STIRRUP, F.G.S. Fossils from the Palæozoic Rocks of America (Indiana) 331

Paper. J. S. BURROWS, M.E. Accidents in Mines and their Prevention. Part 2. 336

Paper. J. S. MARTIN, F.G.S. On the Effect of Atmospheric Changes upon Development of Firedamp 351

Ordinary Meeting, January, 1886 373

Paper. A. H. LEECH, M.E. Screening Arrangements at Brinsop Hall Collieries.. 373

Paper. GEORGE WILD. On Sinking with a Tail Rope .. 380

Discussion 385

Paper. GEORGE WINSTANLEY, M.E. On a Gauzeless Safety Lamp.. 386

Paper. WILLIAM CLIFFORD, M.E. Testing a New Safety Lamp 389

Extra Meeting at Owens College, 26th January, 1886 .. 395

The Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY

M 26

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME EIGHTEENTH,

PARTS I.—XX. 1884-85-86.

MANCHESTER:

SOLD AT THE ROOMS OF THE SOCIETY,

36, GEORGE STREET, MANCHESTER.

MDCCCLXXXVI.

212964

*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

THE LIBRARY

CONTENTS OF VOL. XVIII.

PAGE

Annual Meeting, 7th October, 1884 1

,, ,, 6th October, 1885 237

Report of the Council for Session 1883-84 1

,, ,, ,, 1884-85.. 237

Treasurer's Balance Sheet for Session 1883-84 5

,, ,, ,, 1884-85.. 241

List of Papers, &c., read during the Sessions .. .... 8 & 244

Officers and Council for 1883-84 and 1884-85 .. .. .. 7 & 243

Past Presidents of the Society.. .. ..10 & 246

List of Members .. ..11 & 247

Presentations to the Library, 1884-85 256

Additions to the Library, 1884, 1885-86..45, 121, 175, 207, 325, 491

Societies with whom Transactions are Exchanged .. ..25 & 263

Ordinary Meeting, November, 1884 29

President's Address 29

Coal Dust in connection with Colliery Explosions.. 34

Discussion on the Mineral Veins of the Lake District 38

Ordinary Meeting, December, 1884 45

Paper. Professor W. B. Dawkins, F.R.S. On some Deposits of Apatite near Ottawa, Canada 47

Paper. C. E. De Rance, F.G.S. On the Occurrence of Brine in the Coal Measures.. 61

Paper. J. S. Martin, F.G.S. On an Automatic Safety Lamp.. 82

PAGE.

Ordinary Meeting, January, 1885 85

Paper. J. S. Burrows, M.E. On an Automatic Safety Lamp 85

Paper. Arnold Budenberg. Description of Steel Tube Gauge for High Pressures 96

Extra Meeting at Owens College, January 13th, 1885 101

Address. Professor W. B. Dawkins, M.A., F.R.S. The Carboniferous Flora 101

Address. Professor W. C. Williamson, LL.D., F.R.S. 113

Ordinary Meeting, February, 1885 121

Paper. G. H. Kinahan, M.R.I.A. On a Possible Genesis of the Canadian Apatite 123

Paper. Mr. G. A. Kinahan. On the Apatite Deposits near Ottawa 132

Discussion 135

Discussion on Mr. De Rance's Paper 140

Ordinary Meeting, March, 1885 149

Paper. Mr. John S. Burrows. On Accidents in Mines and their Prevention 150

Discussion 162

Excursion to Sheffield and Aldwarke 169

Ordinary Meeting, April, 1885 175

Discussion on Mr. J. S. Burrows' Paper on Accidents in Mines 176

Safety Lamp Experiments at Aldwarke 186

Paper. Mark Stirrup, F.G.S. On Coal and Coal Plants .. 189

Ordinary Meeting, May, 1885 197

Discussion on Accidents in Mines 197

Ordinary Meeting, June, 1885 207

Paper. R. T. Burnett, F.G.S. The Age of the Rocks of St. David's 209

Discussion 228

PAGE.

Discussion on Mr. Stirrup's Paper on Coal and Coal Plants.. 232

Paper. The Fossil Insects of the Primary Group of Rocks. CHARLES BRONGNIART, F.E.S. (translated by MARK STIRRUP) 269

Discussion.. 289

Footprints in Sandstone Flag. H. M. ORMEROD, F.G.S. 293

Paper. G. C. GREENWELL, F.G.S. Geology of the Island of Jersey 295

Discussion.. 300

Paper. W. E. GARFORTH, M.E. On Working Coal by Long-wall 302

Discussion.. 322

Ordinary Meeting, December, 1885 325

Discussion. M. Charles Brongniart's Paper on Fossil Insects. 328

Paper. MARK STIRRUP, F.G.S. Fossils from the Palæozoic Rocks of America (Indiana) 331

Paper. J. S. BURROWS, M.E. Accidents in Mines and their Prevention. Part 2. 336

Paper. J. S. MARTIN, F.G.S. On the Effect of Atmospheric Changes upon Development of Firedamp 351

Ordinary Meeting, January, 1886 373

Paper. A. H. LEECH, M.E. Screening Arrangements at Brinsop Hall Collieries.. 373

Paper. GEORGE WILD. On Sinking with a Tail Rope .. 380

Discussion 385

Paper. GEORGE WINSTANLEY, M.E. On a Gauzeless Safety Lamp.. 386

Paper. WILLIAM CLIFFORD, M.E. Testing a New Safety Lamp 389

Extra Meeting at Owens College, 26th January, 1886 .. 395

PAGE.

Paper. THOMAS WARD. On Rock Salt 396

Discussion.. 419

Ordinary Meeting, February, 1886 429

Improved Safety Lamps 429

Discussion on W. E. Garforth's Paper 430

Discussion on J. S. Burrows' Paper 437

Paper. GEORGE WILD, M.E. Section through Middle Coal Measures at Bardsley Colliery, and an interesting Discovery of Calamites 446

Discussion 464

Ordinary Meeting, March, 1886 465

British Association Meeting at Aberdeen, 1885. Delegate's Report 466

Discussion on J. S. Martin's Paper "Effects of Atmospheric Changes upon Development of Firedamp" 471

Paper. WILLIAM CLIFFORD, M.E. Description of New Safety Lamp.. 477

Paper. THOMAS CONNOLLY, E.E. The Progress of Electric Lighting in Mines 479

Ordinary Meeting, April, 1886 491

Discussion on Mr. Wild's Paper "Section of Middle Coal Measures at Bardsley, and Discovery of Calamites" .. 495

Ordinary Meeting, May, 1886 507

Paper. HENRY HALL, H. M. Inspector of Mines. On the Fracture of Safety Lamp Glasses 508

Discussion 512

Paper. C. F. CLARKE, M.E. Notes on Brown's Safety Catch for Wire Rope Guides 515

Discussion 517

Ordinary Meeting, June, 1886 519

PAGE.

Paper. M. MERCIER, C.E. On a New Safety Lamp 521

Discussion.. 524

Paper. Professor W. B. DAWKINS, M.A., F.G.S. On the Formation of Agates 525

Discussion. Mr. Connolly's Paper on Electric Lighting in Mines.. 530

INDEX TO VOL. XVIII.

PAGE

Additions to the Library 256, 325, 491

Annual Meeting, October, 1884 1

,, ,, 1885.. 237

BRONGNIART, CHARLES :—

Fossil Insects of the Primary Group of Rocks (with plate) 269

Discussion 289, 328

BUDENBERG, ARNOLD :—

Description of Steel Tube Gauge for pressures of 120 lbs. to 10 tons on the square inch.. 96

BURNETT, R. T. :—

On the Question of the Age of the Rocks of St. David's 209

Discussion 228

BURROWS, J. S. :—

Notes on an Automatic Safety Lamp 85

Discussion 90

Accidents in Mines and their Prevention. Part 1— Explosions.. 150

Discussion 162, 176

Accidents in Mines. Part 2 336

Discussion 437

CLARKE, C. F. :—

Notes on Brown's Safety Catch for Wire Rope Guides.. 515

Discussion 517

PAGE.

CLIFFORD, WILLIAM :—

Testing a New Safety Lamp 389

Description of New Safcty Lamp 477

CONNOLLY, THOMAS :—

The Progress of Electric Lighting in Mines 479

Discussion 530

DAWKINS, W. BOYD :—

On some Deposits of Apatite near Ottawa, Canada .. 47

Discussion 56, 135

The Carboniferous Flora 101

On the Formation of Agates 525

DE RANCE, C. E. :—

On the Occurrence of Brine in the Coal Measures, with some remarks on Filtration 61

Discussion 81, 140

Excursion to Sheffield and Aldwarke 169

GARFORTH, W. E. :—

On Working Coal by Long-wall.. 302

Discussion.. .. .. 322, 430

GREENWELL, G. C. :—

President's Address 29

Notes on the Geology of the Island of Jersey 295

Discussion 300

HALL, HENRY :—

Notes on the Fracture of Safety Lamp Glasses through varying temperatures and other causes 508

Discussion 512

KENDALL, J. D. :—

Discussion—On Mineral Veins of Lake District 38

PAGE.

KINAHAN, G. H. :—

On a Possible Genesis of the Canadian Apatite 123

KINAHAN, G. A. :—

Notes on the Apatite Deposits near Ottawa 132

Discussion.. 135

LEECH, A. H. :—

Description of Screening Arrangements at Brinsop Hall Collieries 373

List of Members 11, 247

MARTIN, J. S. ;

Action of Coal-dust in connection with Colliery Explosions 34

On an Automatic Safety Lamp 82

On the Effect of Atmospheric Changes upon the Development of Firedamp 351

Discussion 471

MERCIER, M. :—

On a New Safety Lamp 521

ORMEROD, H. M. :—

Footprints in Sandstone Flag 293

Owens College Museum Meetings 101, 395

Safety Lamp Experiments at Aldwarke.. 186

Societies with whom Transactions are Exchanged 25, 263

STIRRUP, MARK :—

On Coal and Coal Plants.. 189

Discussion 232

On some Fossils from the Palæozoic Rocks of America, principally from State of Indiana 331

Delegate's Report, British Association Meeting, Aberdeen 466

PAGE.

WARD, THOMAS:—

On Rock Salt.. 396

Discussion.. 419

WILD, GEORGE:—

On Sinking with a Tail Rope 380

On Section of Shaft sunk through the Middle Coal Measures at Bardsley Colliery and an interesting Discovery of Calamites 446

Discussion 464, 495

WILLIAMSON, W. C.:—

The Carboniferous Flora 113

Calamites *versus* Calamodendron.. 501

WINSTANLEY, ROBERT:—

On a Gauzeless Safety Lamp 386

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XVIII. SESSION 1884-5.

ANNUAL MEETING of the Members, held at the Rooms of the Manchester Literary and Philosophical Society, October 7th, 1884:

J. DICKINSON, Esq., F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were elected ordinary members of the Society, viz.:—

JAMES ALDRED, Colliery Manager, Withins Lane Colliery, Radcliffe.

JOHN AINSWORTH, Colliery Manager, Walkden.

Mr. J. S. MARTIN, Hon. Sec., read the report of the Council, as follows:—

REPORT OF THE COUNCIL.

SESSION 1883-84.

The Society has during the Session just concluded continued to make satisfactory progress.

The work done has maintained the high standard of previous years. Notwithstanding deaths, resignations, and removals, the number of members has increased satisfactorily; and the applications received requesting exchange of publications with many of the most important societies both at home and abroad is a pleasing indication of the position which the Society has now attained.

The attention directed in recent years to the question of Miners' Safety Lamps has resulted in several being brought under the notice of the members during the Session. The Marsaut, Pieler, and Wolf lamps are perhaps the more important of them,—the Marsaut from the high degree of safety and lighting power, which it has proved to afford under the varying tests to which it has been subjected; the Pieler lamp on account of the small quantity of fire-damp which it is able to indicate; and the Wolf lamp from the fact of its containing within itself the means of re-lighting without the necessity of opening the lamp or exposing the flame to the outside atmosphere. This latter speciality, if found not to create a source of danger, will prove a boon to miners, who frequently are employed at long distances from the lamp stations.

The paper by Mr. Kendal which has been published "On the Mineral Veins of the English Lakes District" lays important information before the members, and raises questions of no small importance to the geologist, as well as to the miner

Your Council regrets that the interest evinced at the early meetings held at Wigan has not been sustained, but trusts that it has fallen off through temporary causes only, and that it will revive during the ensuing Session.

It has been decided that during the ensuing Session two meetings only, instead of three as last year, shall be held at Wigan; and it is hoped that the members will come forward with papers, and otherwise assist in maintaining the usefulness of the Society.

An Excursion was proposed to the neighbourhood of Stoke-on-Trent in August, but apparently the time fixed was not convenient, and in consequence of the very small number of members who notified their intention to take part, it was thought desirable to postpone it.

It is pleasing to find that the Treasurer's Statement is a sat-

isfactory one, £84 8s. 5d. remaining in hand, notwithstanding that £108 7s. 6d. has been applied to the purchase of £100 Lancashire and Yorkshire Consolidated 4 per Cent. Preference Stock, thus adding to the investments of the Society.

A Publishing Account for £45 6s. 5d. was still outstanding when the accounts were made up, thus reducing the actual balance to £39 2s.

The Library has continued to increase as heretofore by presentations, exchanges, and purchases.

The additions have been so numerous since the present Catalogue was prepared by Mr. Plant (one of our members and at that time one of the Hon. Secretaries) that the preparation of a new or revised one, with the additions, will soon have to be undertaken in order to render the Library of that service to the members which it is desirable it should be.

Your Council wishes to remind members that under the Rules of the Society books can be taken out of the Library for a month; and that for the convenience of those living at a distance books will be forwarded, on application to the Hon. Secretaries, by parcel post or parcel delivery at the risk and expense of the members requiring them.

The Council has to regret the death of several very active and much respected Members during the Session.

His Grace the Duke of Buccleuch, K.G., a life member since 1862, (connected with the district by reason of his large mineral property) was much interested in all that tended to develop the working of mines and quarries, as well as the scientific observations which such workings enabled geologists to become acquainted with.

Mr. John Aitkin, J.P., a member since 1863, was one of the most active members and regular attendants at the meetings. He occupied the Presidential chair in the years 1869-70-71, and again in 1882-83. Having a slight

The attention directed in recent years to the question of Miners' Safety Lamps has resulted in several being brought under the notice of the members during the Session. The Marsaut, Pieler, and Wolf lamps are perhaps the more important of them,—the Marsaut from the high degree of safety and lighting power, which it has proved to afford under the varying tests to which it has been subjected; the Pieler lamp on account of the small quantity of fire-damp which it is able to indicate; and the Wolf lamp from the fact of its containing within itself the means of re-lighting without the necessity of opening the lamp or exposing the flame to the outside atmosphere. This latter speciality, if found not to create a source of danger, will prove a boon to miners, who frequently are employed at long distances from the lamp stations.

The paper by Mr. Kendal which has been published "On the Mineral Veins of the English Lakes District" lays important information before the members, and raises questions of no small importance to the geologist, as well as to the miner

Your Council regrets that the interest evinced at the early meetings held at Wigan has not been sustained, but trusts that it has fallen off through temporary causes only, and that it will revive during the ensuing Session.

It has been decided that during the ensuing Session two meetings only, instead of three as last year, shall be held at Wigan; and it is hoped that the members will come forward with papers, and otherwise assist in maintaining the usefulness of the Society.

An Excursion was proposed to the neighbourhood of Stoke-on-Trent in August, but apparently the time fixed was not convenient, and in consequence of the very small number of members who notified their intention to take part, it was thought desirable to postpone it.

It is pleasing to find that the Treasurer's Statement is a sat-

isfactory one, £84 8s. 5d. remaining in hand, notwithstanding that £108 7s. 6d. has been applied to the purchase of £100 Lancashire and Yorkshire Consolidated 4 per Cent. Preference Stock, thus adding to the investments of the Society.

A Publishing Account for £45 6s. 5d. was still outstanding when the accounts were made up, thus reducing the actual balance to £39 2s.

The Library has continued to increase as heretofore by presentations, exchanges, and purchases.

The additions have been so numerous since the present Catalogue was prepared by Mr. Plant (one of our members and at that time one of the Hon. Secretaries) that the preparation of a new or revised one, with the additions, will soon have to be undertaken in order to render the Library of that service to the members which it is desirable it should be.

Your Council wishes to remind members that under the Rules of the Society books can be taken out of the Library for a month; and that for the convenience of those living at a distance books will be forwarded, on application to the Hon. Secretaries, by parcel post or parcel delivery at the risk and expense of the members requiring them.

The Council has to regret the death of several very active and much respected Members during the Session.

His Grace the Duke of Buccleuch, K.G., a life member since 1862, (connected with the district by reason of his large mineral property) was much interested in all that tended to develop the working of mines and quarries, as well as the scientific observations which such workings enabled geologists to become acquainted with.

Mr. John Aitkin, J.P., a member since 1863, was one of the most active members and regular attendants at the meetings. He occupied the Presidential chair in the years 1869-70-71, and again in 1882-83. Having a slight

acquaintance with mining, he took a deep interest in all subjects connected with it brought before the meetings, but geology was really the science in which he was most interested. He was a close observer of nature, and he has contributed the results of such observations in several papers read before the Society, especially in connection with points of local interest.

Mr. Crowther became a member in 1860.

Mr. J. E. Forbes, F.G.S., a member since 1857. Although not appearing before the Society as a contributor of papers, he was no less an active member, as evinced by the long number of years, about 17, during which he performed the duties of an Hon. Secretary. He also occupied the position of President during the Session 1878-79.

Mr. Thomas Knowles, M.P., a member since 1858, was President during the Session 1873-74. He was one of those bright examples which show what can be obtained through intellect, perseverance, and hard work. Commencing as a boy in a coal mine, he rose through the varying grades of servant to owner, and afterwards became member of Parliament for his native borough, as well as occupying some of the most important posts in the management of our railways and other industrial undertakings.

Mr. John Lancaster became a member in 1858, the same year as Mr. Knowles, and was also at one time member of Parliament for Wigan

Mr. Merfyn became a member in 1881.

Mr. J. T. Seddon, a member since 1873, was for some years an active member of the Council, and took a lively interest in the Society. The melancholy circumstances under which his death occurred, while returning from rendering assistance at the Altham Colliery Company's Mine on the occasion of the explosion in November last, surrounds it with an especial gloom.

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

1883-4.	Abstract of Receipts.	£	s.	d.
October.—To	Balance brought down	126	2	9
,,	Birkenhead Dividends	23	10	0
,,	Lancashire and Yorkshire Dividends	7	16	8
,,	Sale of Transactions	1	13	6
,,	Subscriptions	167	10	0
,,	Arrears	15	18	0
,,	Bank Interest	1	11	0
		£344	1	11
1884.				
October.—To	Balance brought down	£84	8	5

1883-4.	Abstract of Payments.	£	s.	d.
October.—By	Library	7	10	8
,,	Transactions	36	14	9
,,	Reporters	13	4	6
,,	Circulars, Stationery, &c.	9	11	3
,,	Postages, &c.	22	6	9
,,	Meetings—Extra Expenses	1	5	0
,,	Collectors' Commission	9	3	5
,,	Rent, &c.	30	0	0
,,	Attendance, Library	2	10	0
,,	Purchase of Stock	108	7	6
,,	Bill omitted 1882-3, J. Roberts, Printer, &c.—Diplomas	12	18	2
		6	1	6
		£259	13	6
,,	Balance carried down	84	8	5
		£344	1	11

The Investments consist of £600 Four per Cent. Guaranteed Stock of the Birkenhead Railway, and £200 Lancashire and Yorkshire Consolidated Four per Cent. Preference Stock, in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct,

HENRY M. ORMEROD, Hon. Treasurer.

15th September, 1884.

ALFRED PILKINGTON, Hon. Auditor.

21st October, 1884.

	£	s.	d.		£	s.	d.
To Arrears left, 1873, September ..	36	18	0	By Subscriptions received to September, 1884	183	8	0
,, Members as by Account	201	0	0	,, Members dead or discontinued ..	15	0	0
,, New Members...	16	0	0	,, Members in arrear	59	0	0
,, New Members, half-year, 7 ..	3	10	0				
	£257	8	0		£257	8	0

ARREARS REMAINING OCTOBER, 1884.

		£	s.	d.
40	for 1883-4	£40	0	0
12	,, 1882-3	12	0	0
4	,, 1881-2	4	0	0
1	,, 1880-1	1	0	0
1	,, 1879-80	1	0	0
1	,, 1878-9	1	0	0
59	Total Arrears..	£59	0	0

Mr. TONGE moved that the Report of the Council and the Treasurer's Statement be received and adopted.

Mr. BURNETT seconded the motion, and, in doing so, said he should like to refer to that part of the report which expressed regret at the death of some members of the Association. He wished particularly to bear personal testimony to the kindness and ever willing conduct of one who to him (the speaker), as well as to others, was always ready to render generous assistance—he referred to the late Mr. Aitken. To that gentleman he was personally beholden for many kind acts here and elsewhere; and it was the least they could do to render this slight tribute to his memory.

The CHAIRMAN: I am sure, gentlemen, we shall agree with what Mr. Burnett has said respecting Mr. Aitken. His loss will be a very great one for this Society.

The resolution for the adoption of the report and accounts was then put to the meeting and carried unanimously.

The CHAIRMAN: The election of members of the Council rests with the Society. The Council have given the subject their careful consideration, and after striking out the names

of those gentlemen who, in accordance with the rules, have become disqualified owing to the smallness of their attendances, they have agreed to submit a list of names of members eligible for the various offices. The following were then proposed, and declared unanimously elected:—

President:

G. C. GREENWELL, F.G.S.

Vice-Presidents:

W. S. BARRETT.
HENRY HALL.
CLEGG LIVESEY.
H. A. WOODWARD.

Ex-Officio Vice Presidents:

JAMES HEYWOOD, F.R.S. | ANDREW KNOWLES.
G. W. ORMEROD, F.G.S. | JOHN KNOWLES, M.Inst.C.E.
JOSEPH DICKINSON, F.G.S. | W. BOYD DAWKINS, F.R.S.
R. CLIFFORD SMITH, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. K. SHUTTLEWORTH, BART.
GEORGE GILROY, M.Inst.C.E.
EDWARD PILKINGTON, J.P.

Hon. Treasurer:

HENRY MERE ORMEROD, F.G.S.

Hon. Secretaries:

JOSEPH S. MARTIN, F.G.S. | MARK STIRRUP, F.G.S.

Other Members of the Council:

WILLIAM BRYHAM, J.P. | JOHN L. HEDLEY.
R. T. BURNETT, F.G.S. | GEORGE PEACE.
G.C.GREENWELL, Junr., F.G.S. | JAMES RADCLIFFE.
THEODORE D. GRIMKE. | JAMES TONGE, F.G.S.
G. H. HOLLINGWORTH, F.G.S. | WILLIAM WATTS, F.G.S.
CHARLES HARDWICK | GEORGE WILD.

Hon. Auditors:

ALFRED PILKINGTON. | JAMES ATHERTON.

The following resolution was moved by Mr. GARSIDE, and seconded by Mr. BURNETT:—

That the best thanks of the meeting be given to the President and other officers of the Society for their services during the past year.

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

ORDINARY MEETINGS DURING THE SESSION 1883-4.

1883.	
October.	Account of Excursion of Members to Liverpool and the Mersey Tunnel.
November.	Dickinson, Joseph, F.G.S. "On the Marsaut Safety Lamp."
	Still, Frank M. "On the Use of Lime Cartridges as a means of breaking down Coal."
	Thompson, Joseph. "On the Electric Anemometer and Tell Tale."
December.	Williams, E. Leader, M.Inst.C.E. Geological Section of the Mersey and Irwell Valleys.
	Wild, George. "On Sigillaria (Pit Holes) and their detection in the Roof of a Coal Seam by their Stigmarian Roots."
	Brown, W. "On a Patent Safety Catch for Wire Rope Guides in Shafts."
1884.	
January.	Cockson, Charles, M.E. "On a New Ventilating Fan."
February.	Dickinson, Joseph, F.G.S. "On the Marsaut Safety Lamp." Further Notes.
	Le Neve Foster, Dr. C. "On the Pieler Safety Lamp for Indicating small quantities of Fire Damp."
March.	Hall, Henry. "On what will the Royal Commission Report as to Lighting and Blasting in Mines?"
	Le Neve Foster, Dr. C. "On the Wolff Safety Lamp and the contrivance for lighting it."
April.	"On Miners' Safety Lamps."
	Stirrup, Mark, F.G.S. "On Ripple Marks in the Drift."
	Kendall, J. D., C.E., F.G.S. "On the Mineral Veins of the Lake District."
May.	Knowles, John, M.Inst.C.E. "On an Electric Current down Rivin (Pit) Colliery, near Bolton."
	Peace, G. H. "On the Underground Haulage at the Astley and Tyldesley Collieries."
June.	Meeting adjourned.

NEW ORDINARY MEMBERS.

Bancroft, Henry
Crankshaw, Joseph
Edmondson, Robert Holt
Garside, Sampson
Green, George
Hall, Jonathan
Hewitt, John R.
Howatt, Andrew
Hughes, Owen
Isherwood, Jonathan
Jobling, Albert
Jobling, Henry
Jobling, John
Johnson. M. G.
Leach, A. H.
Lyon, Edward
Mc.Adoo, John
Peace, William Henry
Pigott, J.
Rogers, William
Roscoe, James
Simpson, W. W.
Still, Frank M.
Toman, Daniel
Worthington, Henry

MEMBERS DECEASED.

His Grace the Duke of Buccleuch, K.G. *(Life Member).*

Aitken, John, J.P.
Crowther, Samuel
Forbes, John E., F.G.S.
Grundy, Joseph
Knowles, Thomas, M.P.
Lancaster, John, F.G.S.
Merfyn, A.
Seddon, F. J.

MEMBERS RESIGNED, &c.

Ashworth, Edward
Ashworth, James
Bradley, F. Lewis
Bromley, Thomas
Carter, James
Clayton, Abel
Gilroy, S. B.
Grimshaw, H. S.
Melling, William
Wadham, Edward

PAST PRESIDENTS OF THE SOCIETY.

Year of E'ection.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3, 77-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.

LIST OF MEMBERS.

OCTOBER, 1884.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Baxenden Collieries, near Accrington.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton. *Hon. Auditor.*
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1883	Bancroft, Henry, C.E., Moor Lane, Kersal, Manchester.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool. *Vice-President.*
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1879	Baxter, Henry, Tyldesley Colliery, Tyldesley.
1858	Bazley, Sir Thomas, Bart., Riversleigh, Lytham.
1877	Beswick, James, Shakerley Collieries, Tyldesley.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Newchurch, near Manchester.
1880	Boot, John Thomas, The Orchards, Hucknall, Huthwaite, near Mansfield.
1878	Bradford, The Right Hon. the Earl of, Weston Park, near Shifnal.

Year of Election.	
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernest Vanden*, 124, Rue Terre Neuve, Brussells.
1877	*Brongniart, Charles*, Museum d'Histoire Naturelle, 57, Rue Cuvier, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm. Speakman, 14, Trevelyan Bank, Abbey Grove, Eccles.
1859	Bryham, William, J.P., Ince Hall, Wigan. *Member of Council.*
1881	Bryham, Wm., jun., Douglas Bank Colliery, Wigan.
1882	Burnett, R. T., F.G.S., Cresswell Grove, Albert Park, Didsbury. *Member of Council.*
1879	Burns, Thomas, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Yew Tree House, Atherton, near Manchester.
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1882	Cockson, Charles, King Street, Wigan.
1878	Cooke, Charles, Twycross, Atherstone, Leicestershire.
1859	*Coulthart, John Ross, F.R.S.,Lit., F.S.A.,Scot., Greenlaw Park, Castle Douglas, Kirkcudbrightshire, N.B.
1878	Cowburn, Henry, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1880	Crompton, William, Ince, near Wigan.
1862	Cross, John, 77, King Street, Manchester.
1882	Cunliffe, James, Duxbury Park Colliery, Chorley.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.

Year of Election.	
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley, Liverpool.
1882	Devonport, John, Chamber Collieries, Oldham.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1880	Duncan, William, M.D., Prospect House, Tyldesley.
1883	Edmondson, Robert Holt, 28, York Street, Manchester.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Old Hall, near Manchester.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskillen, The Right Hon. the Earl of*, F.R.S., Florence Court, Fermanagh.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1880	Fairley, Joseph Smith, 64, Victoria Street, Liverpool.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1873	Garforth, W. E., Colliery Offices, Normanton.
1884	Garside, Sampson, Denton and Houghton Collieries, Denton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Woodlands, Parbold, Wigan. *Past-President.*
1882	Glover, B. B., Haydock, near St. Helens.
1881	Goodall, John, Handsworth, Woodhouse, near Sheffield.

Year of Election.	
1884	Green, George, Tyldesley Colliery, Tyldesley.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1882	Gresley, W., Stuckley, F.G.S., Overseal, Ashby-de-la-Zouch.
1863	Greenwell. G. C., F.G.S., Duffield, Derby. *President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport. *Member of Council.*
1879	Greenwood, John, jun., Ashton Moss Colliery, Audenshaw, Manchester.
1879	Gregson, Edward, 11, Chapel Street, Preston.
1883	Greensmith, T., Moston Colliery, Failsworth, Manchester.
1880	Grimke, Theodore Drayton, Golborne Hall, Newton-le-Willows. *Member of Council.*
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1879	*Guibal, Theophile*, Professeur d'Exploitation des Mines, Mons, Belgium.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Vice-President.*
1877	Handsley Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester. *Member of Council.*
1880	Hargreaves, John, Collyhurst Paper Mills, Manchester.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1882	Heathcote, William, Farnworth, near Bolton.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester. *Member of Council.*
1875	Hetherington, Joseph, 22 Booth Street, Manchester.
1883	Hewitt, John R., Mining Engineer, Derby.
1874	Hewlett, W. H., Wigan Coal and Iron Company, Wigan.
1880	Heys, James, Westleigh, Leigh, near Manchester.

Year of Election.	
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, Wigan Coal and Iron Company, Wigan.
1878	Holden, Charles H., Mawdsley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., Hollinwood, Manchester. *Member of Council.*
1884	Howatt, Andrew, 25, Mill Street, Ancoats, Manchester.
1878	Howell, John, Astley, near Manchester.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward,* M.A., F.R.S., 5, Raglan Road, Dublin.
1880	Hulton, W. W. B., J.P., Hulton Park, near Bolton.
1883	Isherwood, Jonathan, Tyldesley.
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester.
1875	Jackson, J., 5, Wood Street, Bolton.
1880	Jackson, William, 75, Broadway Street, Oldham.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton.
1884	Johnson, M. G., Rainhill, Prescott.
1882	Johnson, William, Abram Colliery, Wigan.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1880	Kennedy, Matthew, 79, Broadway Street, Oldham.
1882	Kenney, George, 11, King Street, Wigan.
1879	*Kinahan, G. H.,* M.R.I.A., Lurgybrack, Letterkenny, Ireland.
1856	Knowles, Andrew, Swinton Hall, Swinton, near Manchester. *Past-President.*

Year of Election.	
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury. *Past-President.*
1882	Knowles, Israel, Ince, Wigan.
1877	Knowles, Lees, M.A., LL.M., Westwood, Pendlebury.
1884	Leach, A. H , Brinsop Hall Colliery, Wigan.
1862	Livesey, Clegg, Poise House, Torkington, near Stockport. *Vice-President.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1878	Longbotham, Jonathan, Norley Colliery, Wigan.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 4, Albion Place, Leeds.
1884	Lyon, Edward, Royton, near Oldham.
1884	McAdoo, John, Colliery Manager, Hagside, Radcliffe.
1881	McAlpine, G. W., Whinney Hill Colliery, Accrington.
1878	Maiden, Sampson, Bridgewater Villas, Stockport.
1873	Martin, Joseph S., F.G.S., H.M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1883	Mather, William Penn, Iron Works, Salford.
1876	Moore, Alfred, C.E., 5, Clarence Street, Manchester.
1874	*Morton, G. H.*, F.G.S., 122, London Road, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth. *Past-President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *Hon. Treasurer.*
1874	*Owen, Sir Richard*, D.C.L., F.R.S., Sheen Lodge, Richmond Park, London, S.W.
1862	Park, James, Fern Hill, Bury.

Year of Election.	
1880	Parish, Arthur Woodbine, Clowes House, Higher Broughton, Manchester.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grove, Eccles. *Member of Council.*
1877	Peace, Maskell W., F.G.S., Wigan.
1883	Peace, William Henry, Monton Grove, Eccles.
1881	Pearson, A., Dukinfield Cottage, near Ashton-under-Lyne.
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1881	Pennington, A. S., Wood Street, Bolton.
1877	Pennington, Rooke, F.G.S., 14, Acresfield, Bolton.
1882	Percy, C. M., F.G.S., 25, King Street, Wigan.
1878	Perrin, J. Beswick, M.R.C.S.E., F.L.S., Leigh, near Manchester.
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester. *Hon. Auditor.*
1879	Pilkington, Charles, Ashton and Edge Green Collieries, St. Helens.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Astley Deep Pit, Dukinfield. *Member of Council.*
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1882	Rigby, William, Leader's Buildings, King Street, Wigan.
1877	Robins, George, Ashton, near Newton-le-Willows.
1884	Rogers, William, King Street, Wigan.
1884	Roscoe, James, Little Hulton, Bolton.
1882	Sacré, R. A., 20, Cooper Street, Manchester.

Year of Election.	
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1881	School of Mines, Columbia College, New York. The President (for the time being) of the. (To be addressed to Mr. H. Grevel, 33, King Street, Covent Garden, London.)
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Darcy Lever Collieries, Bolton.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1883	Shortrede, Thomas, Winstanley, near Wigan.
1884	Simpson, W. W., Church, Accrington.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	Smethurst, William, F.G.S., Langate House, Brynn, near Wigan.
1838	Smith, G. F., M.A., F.G.S., Grovehurst, Tunbridge Wells.
1881	Smith, John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1881	Squire, J. B., A.Inst.C.E., 1, Sibella Road, Clapham, London, S.W.
1859	Statter, Thomas, Stand Hall, Bury.
1883	Still, Frank Murray, 3, Queen Street, Cheapside, London.
1880	Stirrup, Mark, F.G.S., Richmond Hill, Bowdon. *Hon. Secretary.*
1882	Stopford, T. R., Park Hall Colliery, Blackrod, Lancashire.
1882	Storey, Edward, Leigh, Lancashire.
1881	Taylor, Alfred, Norley Collieries, Wigan.
1880	Teale, William E., Fern Bank, Worsley.
1884	Toman, Daniel, Chamber Colliery, Oldham.

Year of Election.	
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton. *Member of Council.*
1876	Topping, Walter, Bamfurlong Collieries, near Wigan.
1858	*Trafford, Sir Humphrey de, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1877	Waddington, Henry, Burnley Collieries, Burnley.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, 11, King Street, Wigan.
1882	Wallwork, Thomas, Colliery Office, Walkden, near Bolton.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1881	Wanlass, William, Westhoughton, near Bolton.
1879	Warburton, William, High Lane, near Stockport.
1880	Watts, William, F.G.S., Piethorne, Rochdale. *Member of Council.*
1878	Wells, Samuel R., Mining Engineer to the Bengal Coal Co., Ld., Khooldiah Collieries, Giridih, India.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Member of Council.*
1877	Wild, Joseph, 3, Stoneclough Road, Kearsley, near Bolton.
1880	Williams, E. Leader, M.Inst.C.E., Queen's Chambers, John Dalton Street, Manchester.
1876	Winstanley, Robert, 28, Deansgate, Manchester.
1876	Woodward, H. A., Clifton, near Manchester. *Vice-President.*
1884	Worthington, H., Peel Hall Colliery, Little Hulton, Bolton.
1877	Yates, T. M., Anderton Hall Colliery, Blackrod, Chorley.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any corrections or omissions in the list.

PRESENTATIONS TO THE LIBRARY, 1883-84.

Belfast.—Natural History and Philosophical Society. Proceedings for Session 1882-83. *From the Society.*

Bramall, H., M.Inst.C.E.—Modern Progress of Mine Engineering. Pamphlet. *From the Author.*

Bristol Naturalists' Society.—Proceedings. Part 2, Vol. IV., 1883-4. *From the Society.*

Bristol Naturalists' Society.—Annual Report, 1884. *From the Society.*

Cambridge University. — Report of the Museums and Lecture Rooms Syndicate. For 1883.

Chester.—Society of National Science. Annual Report, 13th, 1883-4. *From the Society.*

Chesterfield and Derbyshire Institute of Engineers.—Transactions. Vols. VI.-IX. (bound), X.-XII. (unbound), Part 1, Vol. XIII. *From the Institute.*

Cornwall. — Transactions of the Royal Geological Society of. Part 6, Vol. X. 64th Annual Report, 1883. *From the Society.*

Cornwall. — Royal Institution of. — Journal. Part 1, Vol. VIII., 1882-3. *From the Council.*

Cornwall.—Mining Institute.—Proceedings, Nos. 8 and 9, 1883. *From the Institute.*

Edinburgh Royal Physical Society.—Proceedings. Session 1882-3. *From the Society.*

Edinburgh.—Royal Society.—Proceedings. Session 1881-2 and 1882-3. List of Members, 1883.

Glasgow Natural History Society.—Proceedings. Part 2, Vol. 5. *From the Society.*

Geological Magazine, August and September, 1884. *Purchased.*

Hertfordshire Natural History Society and Field Club.—Transactions. Parts 4 to 9, Vol. II. *From the Society.*

Institution of Mechanical Engineers.—Proceedings. Nos. 1-4, 1883, 1-2, 1884. *From the Council.*

Iron and Steel Institute.—Journal. Nos. 1 and 2, 1883. Catalogue of the Library. *From the Council.*

Leeds Philosopical and Literary Society.—Annual Report, 1883-4. *From the Society.*

Leicester Literary and Philosophical Society.—Transactions for 1870-79. *From the Council.*

Liverpool Geological Association.—Transactions. Session 1882-3. Annual Report, 1883. *From the Association.*

Liverpool Geological Society.—Proceedings, Parts 5 and 6, Vol. IV. *From the Society.*

London Geological Society.—Quarterly Journal. Nos. 156 to 159. Abstracts of Proceedings for the Session 1883-4. List of Fellows (November, 1883). *From the Society.*

London Geologists' Association.—Proceedings. Nos. 2-6, Vol. VIII. *From the Council.*

London.—Royal Institution.—Proceedings. Nos. 75 and 76, Vol. X., Part 2. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 227-231, Vols. XXXV.—XXXVI., Part 232, Vol. XXXVII. *From the Society.*

London.—Science Monthly.—Parts 1-9., Vols. I. and II. *From the Editor.*

London.—Institution of Mechanical Engineers.—Nos. 3 and 4, 1883, and No. 1, 1884. *From the Institute.*

London.—Society for Physical Research. Parts 4, 5, and 6, Vol. 1. *From the Society.*

Manchester Field Naturalists' Society.—Report and Proceedings for 1883. *From the Society.*

Manchester Literary and Philosophical Society. Proceedings, Vols. XX.—XXII. Memoirs, Vol. VII., 3rd series, 1882; Memoirs, Vol. IX. A Centenary of Science in Manchester, by Dr. Angus Smith. *From the Society.*

Manchester Scientific Students' Association.—Report of Proceedings for 1883. *From the Association.*

Midland Institute of Engineers.—Transactions. Parts 69-73, Vol. IX. *From the Council.*

Mining Institute of Scotland. Transactions. Parts 5-9, Vol. V., and 1-4, Vol. VI., 1883-4. Rules and List of Members. *From the Council.*

North of England Institute of Engineers.—Transactions. Part 5, Vol. XXXII. Parts 1-5, Vol. XXXIII. *From the Council.*

Norwich Geological Society.—Proceedings. Part 8, Vol. 1, 1883. *From the Society.*

Peacock, R. A., C.E., F.G.S.—Saturated Steam as the Motive Power in Volcanoes and Earthquakes. *Pamphlet. From the Author.*

Science Monthly.—Illustrated Journal. Parts 1-8, Vol. I., Parts 9-11, Vol. II. *From the Editor.*

South Wales Institute of Engineers. Proceedings. Parts 5-7, Vol. XIII., 1884. *From the Institute.*

Stirrup, Mark.—On the Antiquity of Man in Great Britain. *Pamphlet. From the Author.*

Warwickshire Naturalists' and Archæologists' Field Club.—Proceedings, 1883.

Yorkshire Geological and Polytechnic Society.—Proceedings. Part 2, Vol. VIII., 1883. *From the Society.*

Annual Reports, from the Committees.

Cambridge University. Report for 1882-3.

Cambridge University. Report of Museum and Lecture Rooms Syndicate for 1883.

Devon and Exeter Albert Memorial Museum. Fourteenth Annual Report, year ending April 14th, 1884.

Devon and Exeter Free Library. 1883-4.

Dundee Free Library. 1882-3.

Liverpool Free Library. 1883.

Manchester Owens College Calendar. Session 1883-4.

Manchester Victoria University Calendar. Session 1882-3.

Salford Museum, Libraries, and Parks. 1882-3.

U.S. America and Canada.

Agassiz, Alexander.—Museum of Comparative Zoölogy, Cambridge, U.S.A. Annual Report of the Curator. 1882-3. Bulletin. Nos. 3-4, Vol. XI.

Harvard College.—Bulletin of the Museum of Comparative Zoölogy, No. 10, Vol. II. Bibliography. Acalephs.

Indiana.—Department of Geology and Natural History. Twelfth and Thirteenth Annual Reports by John Collett, State Geologist. *From the Department.*

Montreal Natural History Society.—The Canadian Record, No. 1, Vol. 1. *From the Society.*

New York.—American Institute of Mining Engineers. Memorial of A. L. Holley, C.E. *From the Institute.*

New York.—American Museum of Natural History. Bulletin. Part 5. 15th Annual Report, 1883. *From the Committee.*

Smithsonian Institution, U.S.A.—Annual Report for 1881. *From the Institution.*

Selwyn.—Geological and Natural History Survey of Canada. Report of Progress, 1880-81-82, with Maps. *From A. R. C. Selwyn, F.R.S.*

Toronto.—The Canadian Institute.—Proceedings. Part 5, Vol. I. Parts 1 and 2, Vol. II. New Series. *From the Council.*

Transactions of the American Institute of Mining Engineers.—Vol. XI., 1883. Index Vols. I-X. *From the Council.*

United States.—Compendium of the Tenth Census, 1880. Parts 1 and 2. Third Report of the Entomological Commission, 1883. *From the Government, U.S.A.*

AUSTRALIA.

Melbourne.—Observations of New Vegetable Fossils of the Auriferous Drifts. By Baron F. von Mueller, Government Geologist of Victoria. *From the Department of Mines and Water Supply*, Melbourne.

New Zealand.—Its Mineral Resources. *Pamphlet.* By H. Bramwell, M.Inst.C.E. *From the Author.*

Quarterly Reports of the Mining Surveyors and Registrars, Victoria. June, 1883, to December, 1883, and 1884.

Sydney.—Public Free Library: Report for 1883-4. *From the Committee.*

Victoria.—Mineral Statistics of. 1883.

Victoria.—Report of Chief Inspector of Mines. 1883.

Victoria.—Gold Fields of. Reports of Mining Registrars, June, 1884.

Victoria.—Report of Trustees of Public Library, Museums, and National Gallery of. For 1883.

FOREIGN.

Académie Impériale des Sciences de St. Pétersbourg. Mémoirs. VII. Série Nos. 5-16. Tome XXXI. Nos. 1-3, Tome XXXII. Bulletin Tome XXVIII., Nos. 3 and 4. Tome XXIX., No. 1. *From the Academy.*

Buenos Ayres.—Estadística de Comercio y de la Navegacion de la República Argentina. Statistics of Foreign Commerce. 1882 and 1883. *From the Government.*

Buenos Ayres.—A Statistical and Geographical Review of the Country and its Resources. By Francis Latzina, 1883. *From the Government of the Argentine Republic.*

Christiania.—Royal University of Norway. Catalogue of Books received in 1880-1. Silurfossiler Pressede Konglomerater, af Hans H. Renset. Die Silurischen Etagen, 2-3. Von W. C. Brogger. *From the University.*

R. Accademia dei Lincei.—Transunti. Vol. VII. Fascicolo 15° and 16° and Vol. VIII. Fascicolo 1-15, 1882-83. Memoirs. Vol. XI.-XIII., 1881. *From the Academy.*

Deutsche Geologische Gesellschaft. — Zeitschrift. Hefte 3 and 4, Band XXXV. 1 Heft, Band XXXVI. *From the Society.*

Naturforschende Gesellschaft zu Leipzig.—Sitzungsberichte, 1883. *From the Council.*

Naturwissenschaftliche Gesellschaft Isis in Dresden.—Sitzungsberichte. January to June, 1883. *From the Society.*

Paris.—Revue de la Legislation des Mines, Sep. 1884. *Purchased.*

Rome.—Il Saldame il rego e la terra. *Pamphlet.* Guiseppe Leonardelli, 1884. *From the Author.*

Societá Toscana di Scienze Naturali. Pisa. Memorie. Vol. VI. Fas. ° Processi-Verbali. Vol. IV., Parts 1-3. Indice del, Vols. II. and III. *From the Society.*

Sociéte Royal Malacologique de Belgique:

Annales. Tome XVII., 3rd series, 1882-3. Tome XIII., 2nd series, 1882-3. *From the Society.*

Société Vaudoise des Sciences Naturelles. Lausanne. Bulletin. No. 89, Vol. XIX. No. 90, Vol. XX. 1883. *From the Society.*

Société Géologique du Nord. Lille. Annales. Tome X., 1881-82. *From the Society.*

Van den Broeck. Nouvelles Observations faites dans la Campine en 1883. *Brochure.* Mélanges Géologiques et Paléontologiques. *Brochure. From the Author.*

Verein für Erdkunde zu Halle a/S. Mittheilungen für 1883. *From the Society.*

BOOKS PURCHASED 1883-84.

Geological Magazine. Nos. 232-241. 1883-4.

Hunt's British Mining. Treatise on Metalliferous Mines of United Kingdom.

Palæontographical Society's Monograph. Vol. XXXII.

Revue de la Legislation des Mines. Par Emile Delecroix. Parts 1-3. Mars, Juin, and Sep., 1884.

SOCIETIES WITH WHOM THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHOM A COPY IS SENT FREE.

I.—ENGLAND.

London.....British Museum.
Geological Society.
Geological Survey.
Geologists' Association.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute.
Royal Institution.
Royal Society.
Society for Psychical Research.

Manchester .....Field Naturalists' Society.
Free Library.
Literary and Philosophical Society.
Owens College.
Salford Royal Museum and Library.
Scientific Students' Association.
Barnsley .....Midland Institute of Mining Engineers.
Birmingham.....Free Library and Museum.
Bristol.....Naturalists' Society.
Buckhurst Hill, Essex Essex Field Club.
Camborne.....Miners' Association of Cornwall and Devon.
Cambridge.....Geological Museum, University.
University Library.
Chester.....Society of Natural Science.
Chesterfield .....Institute of Mining Engineers (in bound vols.)
Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.
Dudley.....South Staffordshire and East Worcestershire Institute of Mining Engineers.
Exeter .....Albert Memorial Museum.
Halifax.....Geological and Polytechnic Society.
Leeds.....Philosophical and Literary Society.
Leicester .....Literary and Philosophical Society.
Liverpool.....Free Library and Museum.
Geological Association.
Geological Society.
Newcastle-on-Tyne..Institute of Mining and Mechanical Engineers.
Norwich .....Geological Society.
Oxford.....Bodleian Library.
Radcliffe Library.
North Shields ....Public Free Library.
Redruth .....Mining Institute of Cornwall.
Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea .....South Wales Institute of Mining and Mechanica Engineers.
Warwick .....Natural History Society.

Watford, Herts....Natural History Society and Field Club.
Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee.....Free Library and Museum.
Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.
Glasgow .....Geological Society.
Natural History Society.
Hamilton.....Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast .....Natural History Society.

IV.—Australia.

Melbourne.....Public Library of Victoria.
Sydney.....Free Public Library.
Royal Society of New South Wales.
Newcastle.....John Mackenzie, F.G.S.

Canada and United States.

Montreal .....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College (Principal, J. W. Dawson, F.G.S.)
Philadelphia, U.S...Franklin Institute.
Toronto.....Canadian Institute.
Boston, U.S. ....Free Library.
Columbus, U.S. ..Ohio, Geographical Survey of (Dr. J. S. Newberry).
Easton, U.S. ....American Institute of Mining Engineers.
Indiana, U.S. ....Department of Geology and Natural History John Collett, State Geologist.

Indianapolis, U.S. E. T. Cox, State Geologist.
Newhaven, U.S. ..Professor O. C. Marsh, F.G.S.
New York .....American Museum of Natural History, Central Park.
Washington, U.S. .Department of the Interior U.S. Geological Survey.
Smithsonian Institution.
Wyoming, U.S. ..Historical and Geological Society.

VI.—Foreign Societies.

Berlin .....Deutschen geologischen Gesellschaft.
Buenos Ayres ....Officiana Nacional de Commercie.
Calcutta .....Geological Survey of India.
Christiania .....Royal University of Norway.
Halle, A.S......Verein Fur Erdkunde.
Lausanne (*Suisse*)..Sociétié Vaudoise des Sciences Naturelles.
Lille.....Sociétié Géologique du Nord.
Pisa.....Sociatà Toscana di Scienze Naturali.
Rio de Janeiro....Museu Nacional.
St. Petersburg ....Acadèmie Impèrial.
Turin .....Academie Royale.

VII.—Scientific Journals, &c.

Geological Magazine, Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review, Science Monthly, 3. St. Martin's Place, London, W.C.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XVIII. SESSION 1884-5.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 4th day of November, 1884, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

G. C. GREENWELL, Esq., F.G.S., President, in the Chair.

The HON. SECRETARY stated that, by direction of the Council, Mr. Wm. Smethurst, hitherto an ordinary Member, was proposed for election as a Life Member, without payment.

Having been duly ballotted for, Mr. Smethurst was declared unanimously elected a Life Member.

PRESIDENT'S ADDRESS.

The PRESIDENT, in taking the chair, read the following address:—

Seventeen years ago you elected me your President, and you have again conferred that honour upon me: an honour

of which any man may be proud, and for which I beg of you to accept my hearty thanks. I am afraid that the distance of my residence from Manchester will prevent my regular attendance at your meetings, but I will do my best on all occasions to fulfil the duties which you have placed in my hands. But we cannot walk as we once did: hand and eye begin to fail somewhat, and we gradually find that we must give way to younger blood. However, as Locksley said, "a man can but do his best;" and so long as I do that, I feel that I shall always be able to rely upon the aid and support of the old friends whom I have now the pleasure of addressing.

I have been at all times pleased, when reading the papers that have been contributed to the Manchester Geological Society, to find them maintain the credit of the past, particularly as regards their practical character. Many discoveries have been made, and the object of societies such as this ought to be to endeavour to apply these discoveries as far as the same are applicable to practice. Of this the following may be taken as an example of what I mean: Take electrical lighting and the other results which have been obtained by the agency of electricity.

One of the first practical uses to which this power was applied was when Sir Humphrey Davy discovered by it the true composition of what had formerly been considered elements. Electricity up to that time was a wonderful but somewhat unmanageable and dangerous toy.

I recollect very well, and I daresay some of you do, the divergence of poised needles produced by means of electricity conveyed through long circuits of wire taken round the lecture rooms and class rooms of 50 years ago. Soon afterwards the practical minds of Cook, Wheatstone, and others made that application of what was then a scientific toy to

the establishment of electro-telegraphic communication which eclipses Ariel's fanciful "girdling of the earth in forty minutes."

But further uses were to be made of electricity. It was found out that by its means vibrations producing certain effects upon the ear could be conveyed by the electrical wire for long distances to the ear; and then the telephone became the wonder of the day. And what shall we say of those other applications of this subtle and incomprehensible agency by which we can hear the foot-fall of a fly, or bottle up spoken words.

One of the applications of electricity has greatly exercised people's minds: I mean that to the purposes of illumination. It is not many years since that by the labours of Edison and others, it was first found practicable to adapt the brilliancy and beauty of the electrical light to the lighting of streets and houses. There are many modes of manipulation, each having its advocates, but there is yet much room for improvement. With the electrical light made portable so as to take it into our coal mines, we might conduct our works with greater safety, and I consider it by no means improbable that this result will soon be attained.

I will now venture to approach another part of our general object, and I do it in a spirit which I trust will not be misunderstood.

I am afraid that we are sometimes too prone to theorise. It seems to me to be a great pity that in addition to observing and recording facts of the greatest value we should waste so much of our time in manufacturing theories. I could refer to many papers which have their value considerably diminished by these, and I think that their omission would be most beneficial.

I believe that in most societies of a kindred character to ours, many a member is deterred from preparing and reading a paper because he thinks that, to write something, he must produce something elaborate.

There are few things that pass under our ordinary observation which are not worth recording, and a mere, but accurate, record of such is of the greatest value; and there is not one among us who could not thus contribute to the information of his fellow members.

The chief result of this course of procedure would be the great encouragement which would be given to discussion, owing to the strong probability that similar observations had been made by others, and this would undoubtedly lead to the establishment of facts.

Of course, by the above, nothing is meant to be said to discourage the production of papers; but my wish is to encourage those who do not write them to contribute that which in a remarkable degree would be advantageous to the Society at comparatively little trouble to themselves.

I will give an example taken from my diary of September, 1883:—

Sept. 6th.—"St. Heliers, Jersey: At about 120 yards "down the road from the cemetery gates, and at the right "hand side of the road in going up, the strata consist of a "light mouse coloured shale, of which the water level varies "from N. 70° W. to N. 88° W.; dip S. 30 W. to S. 12 W "at from 37° to 50°.

"Lying about 10 or 12 feet above these beds, and ex- "posed at the other side of the road, are numerous beds of "ironstone, at about 100 yards below the cemetery gates.

"The thickness of the bands of ironstone varies from "3in. to 7in. The water-level here is N. 45° W.; dip S "45° W., 28°.

"Twenty yards further up the road, and on the right "hand side of it, the water-level is N. 34° W., and the dip "S. 56° W., 37°. This section is just below the 1 mile-"stone, and about 70 yards from the cemetery gates, "towards which the direction and dip of the strata continue "the same.

"Towards the top and covering the hill is a sort of loose "breccia, the composition of which is mainly decomposed "granite, there being here and there lumps of decomposed "felspar.

"At about 100 yards from the cemetery gates, and down "Old St. John's Road, the road is cut through rock, the "strata resembling those lying under the ironstone bands, "though probably, owing to a fault, lying at a considerably "higher level. The water-level of these beds is N. 70° W., "dip S. 30° W. at an angle of 35°, but the strata are here "rather confused."

Sept. 10th.—"Near the station at St. Heliers, on the line "to Gorey, there are two whin dykes, which run from the "bottom to the top of the cutting, through the granite, in "a direction nearly E. and W. (mag.). The first dyke is "80 yards from the station; it is 2ft. 6in. thick, and over-"lies to the north at an angle of 80°. The cutting here is "about 120ft. deep. The dyke is a very hard and compact "dark whinstone.

"At 32 yards further from the station there is also an "appearance of whin with specks of pyrites in it, and some "crystals of felspar not well defined. At 58 yards still "further from the station there is another whin dyke, "direction as before, overlying to the north 83°. This dyke "consists of two parts; the northern is 1ft. 8in. thick, a "purple brown whin, and the southern 1ft. 8in. of dark "blue hard flinty whin, like that of the dyke first named.

"The granite has numerous cracks lying here in all "directions, but there pervades a certain kind of stratifica- "tion not entirely irregular: perhaps the mass should be " called gneiss."

I am not, nor I dare say are you, in favour of long addresses. I do not attempt to recapitulate what has been done in the geological world during the last year, but I simply place before you one or two subjects for your consideration, to be viewed more in the light of suggestions than of advice.

I conclude by thanking you for your attention, and with my best wishes for the prosperity of the Manchester Geological Society.

ACTION OF COAL-DUST IN CONNECTION WITH COLLIERY EXPLOSIONS.*

Mr. MARTIN (Hon. Sec.) said that he wished to bring before the meeting an account of some experiments described in the *Gluckauf Berg-und Hüttenmännische Zeitung* of October 8th (ultimo), which were made on the 3rd of the same month before the German Wetter-Commission, at König Grube, near Neunkirchen, in the Saar coalfield, belonging to the Prussian Government.

A gallery has been constructed on the surface 51 metres in length of elliptical form (5½ft. x 4ft.) with a cross gallery to represent the actual state of a colliery level. There are

* Since bringing this subject before the meeting I find that Mr. Galloway, who has long worked upon this subject, and witnessed the experiments in question or subsequent ones, has contributed his observations to *Nature* of the 6th November, to which I would refer members for a more complete description.

windows placed at a distance of one metre apart for observation from the exterior. One end is closed by a massive piece of masonry, in which small cast-iron cannons are placed with bores of the sizes usually used for blasting in mines.

Fire-damp is conducted in pipes 1100 metres, from a blower in the mine, to a gasometer on the surface for the purpose of these experiments.

The Government Inspector of Mines, Herr Margraf, has made some 200 experiments, and is continuing his observations.

The following are the experiments referred to as having been made on the 3rd October, 1884, in which the shots were charged with ½lb. of powder and fired by electricity:—

(1) Stemmed with clay the length of flame was 3 metres.

(2) Stemmed with coal-dust the length of flame was 8 metres.

In these experiments neither coal-dust or fire-damp was present in the gallery.

(3) Stemmed with clay, the gallery being strewn 40 metres in length and 1¼ inches thick with a very non-gaseous coal-dust from Morsbach Colliery, near Aachen (Aix-la-Chapelle), the length of flame was 5½ metres.

(4) Stemmed with coal-dust, and dust strewn in the gallery as in No. 3, the flame was 9½ metres.

(5) Stemmed with clay, the forenamed coal-dust being replaced by dust from Pluto Colliery in Westphalia, where the coking and gas seams are worked, the length of flame was 58 metres, or 7 metres beyond the end of the gallery, accompanied by a strong

detonation and development of a very heavy after-damp.

(6) A repetition of No. 5, without fresh dust being added, gave almost identical results.

(7) Stemmed with clay, and fired, without the presence of coal-dust, in a chamber, of 20 cubic metres content, filled with a well-diffused mixture of fire-damp and air in the proportion of 1 to 20—5 per cent. of fire-damp—the length of flame was about 11 metres.

(8) Similar to No. 7, with the addition that 20 metres of the gallery was strewn with coal-dust as before, from Pluto Colliery, the length of flame was 52 metres, accompanied by an exceedingly severe detonation and a strong development of thick heavy after-damp.

The extraordinary force of the explosions with Pluto coal-dust may be judged of from the fact that (No. 5) without the presence of fire-damp, but with 40 metres of dust, a colliery waggon weighing 6 cwt. placed at the mouth of the gallery was blown 7½ metres along the tram rails, rising with a gradient of 4°; and that (No. 8) with 5 per cent. fire-damp but only 20 metres of the gallery strewn with dust, the waggon was propelled 12½ metres up the 4° gradient, and there thrown off the rails.

The PRESIDENT said they must all be very much obliged to Mr. Martin for his communication. The fact seemed well established that coal-dust was a great contributor to the violence of colliery explosions; but as to how it acted there was some difference of opinion.

Mr. MARK STIRRUP mentioned that inquiries had been pursued in the same direction in this country by Mr.

Galloway, who had stated the results of his experiments before the Royal Society in 1876. His experiments were pretty well known, but whether they were so complete as those undertaken in Prussia he (Mr. Stirrup) could not say. Members would find in the Society's library various works bearing upon this subject. In the recent Transactions of the Chesterfield and Derbyshire Institute, vol. 10, 1882, there was, he knew, a long and interesting report of a Committee of the Institute on this subject.

Mr. MARTIN said he had received a letter from Mr. Galloway stating that the experiments fully confirmed those he had himself made on a smaller scale.

Mr. STIRRUP said that attention had also been drawn to this subject in America, from an explosion not of coal but of flour dust, which was attended with disastrous effects, both to life and property. The explosion was communicated from one mill to another, through the ignition of the dust of flour, and several buildings were destroyed. This seemed to show that the danger was not wholly confined to colliery dust.

Mr. DICKINSON said he did not know that it was worth while his troubling the Society with his views upon this subject, which were, he thought, well enough known. The subject really was not new; it was thirty years ago when he took part in an investigation into the circumstances attending an explosion at one of the Wigan collieries, where 89 lives were lost, that the presence of coal-dust was alleged to be an aggravating cause of the explosion.

DISCUSSION ON MR. KENDALL'S PAPER ON THE MINERAL VEINS OF THE LAKE DISTRICT.

Mr. C. E. De Rance.

(Communicated by the Hon. Sec.)

I regret I am prevented attending your meeting. I regard Mr. Kendall's paper on the mineral veins of the Lake district, not merely as one of the most important papers that has ever been laid before the Society, but as a valuable addition to our knowledge of mineral veins.

To me it is of exceptionable interest, having been myself stationed for two years in the Lake-district in the Ambleside and Coniston area, and having had the advantage of traversing most of the northern area with my former colleague and lamented friend, the Rev. Clifton Ward.

The author has brought together a valuable array of facts, and has contented himself with drawing a limited number of conclusions. His final conclusion that "veins are not filled fissures" will certainly not apply to the veins of Alston Moor, on the opposite side of the Vale of Eden, to the Lake country, where those who have visited the district, or studied it, in the works of Wesgarth Foster, Sopwith, and Wallace, will know there is perfect evidence of the abrupt cracking of the fissure, the steepness of the sides of which have a direct relation to the hardness of the varying layers of the surrounding rock. The walls are marked with deep slick-insides, and these again indicate horizontal as well as vertical motion, as do the "fault-walls" in most coalfields, in some of which, as in Kilkenny and Accrington, I have seen true lead-lodes. In the Lake-district, from the nature of the volcanic rocks, the walls of the veins are not so marked and

apparent, and it is possible that Mr. Kendall may be correct that certain veins are not "filled fissures," but I do not think he has established his case that all are not.

The rocks of the Lake district are, as pointed out by Clifton Ward, traversed by three sets of divisional planes. 1st. *Bedding*, which is the most obscure of all, and has to be looked for carefully, forming the banded stripe, or ribbon like appearance seen in the Tilberthwaite slates described by myself, and later by Mr. Teale, and which in the coarse Breccias—often intensely altered as they are—is seen only here and there, where a slight indication of fragments following each other in a defined line or bed occurs. 2nd. *Cleavage*, these planes form the slates of Langdale and Tilberthwaite, and are present wherever a fine bed of ash comes in, as at Whitemoss, near Grasmere. They dip at high angles, and are taken by the unwary for bedding planes. Between Ambleside and Keswick they are traversed by a series of anticlinal axes, with corresponding synclines, and it is remarkable that, through a coincidence, the strike of the bedding, and the cleavage correspond in direction, but the anticlinals of the one occur in the position of the synclinals in the other. 3rd. *Jointing*. These planes, in the Lake-district lavas and in the altered Breccias, occur in three directions, giving a step or bedding-like appearance to the Yewdale Breccias, in which occur the Copper Coniston Mines. In the Tilberthwaite ash-bed beneath the Breccia, I observed an interesting section in which a vein of white vein-quartz ran for several yards between two cleavage planes, which had been bent and distorted by subsequent pressure; the quartz being unable to bend had broken at all the curves of the contortions, then suddenly it left the cleavage planes, and crossed them, following the line of a nearly horizontal joint, proving the introduction of vein-quartz to be later than the era of cleavage in this district.

Behind the deep Tilberthwaite-glen I found fragments of gold about the size of a small pin's head in a trial of a lead and blend vein by the mountain roadside. The gold has been examined by Mr. Warington Smyth, F.R.S., and Professor Morris, who supported my identification. The rest of the vein-stuff was quartz, and a soapy, magnesian like mineral.

The maps and plans accompanying Mr. Kendall's paper are a valuable addition of facts, that would probably have been otherwise lost.

Mr. STIRRUP said that Mr. Kendall, as Mr. De Rance stated in his communication, had given them a good deal of valuable information, both geologically and with respect to the nature of mineral veins, and their relation to the special rock structure of the Lake district. But he (Mr. Stirrup) did not think they should take Mr. Kendall's opinions with respect to the Lake district to be such as could be applied in every other district, for he had noticed, with regard to lead, that it occurred in that district in association with ash-beds—volcanic rocks—and they all knew that in other districts the mountain limestone was also a very prolific source of lead. Mr. Kendall also spoke against mineral veins being considered as fissures: apparently he could not allow that there was an occurrence at all of what were understood to be filled fissures. Well, if they referred to such rocks as the mountain limestone, they could not call the veins met with there anything else but fissures. Mr. Kendall hazarded some theories upon the age and origin of veins, as to which possibly many exceptions might be taken. Mineralogists had a variety of opinions upon this subject, and he did not think Mr. Kendall's was particularly new. He traced the origin of metalliferous veins to a volcanic source, so far as he (the speaker)

understood the argument; and that they were, as a rule, in connection with volcanic rocks which had been greatly disturbed at some very remote period of the earth's history. Mr. Kendall also referred to the metallic minerals as usually occurring as sulphides, and the sulphide he attributed to a volcanic emanation. There were, however, other and better hypotheses before the public, and which had experimental proof to support them. He personally preferred that of a French chemist, M. Dieulafait—(which was also shadowed forth by others of earlier date) - that the source of the metals occurring in veins was to be sought in the rocks themselves, and not in the depths of the globe. That was a theory which, he thought, would avoid many of the difficulties that arose as to the origin of the metallic minerals, and the same or a similar theory was the one upon which one of our greatest English authorities (J. A. Philips) also relied. It was a theory such as this to which they would have to look for something like truth in the matter, viz., that the metallic particles were in the rocks themselves, in a highly diffused state, and that the veins, or fissures, had been the paths by which the water holding the mineral matter in solution had found its way; thus the water, descending slowly and through vast periods of time, had deposited the metallic particles in its way, and in the places where they were now found. The stratification which they presented in the veins would also, he thought, lead to the same conclusion. Then, with regard to the direction of the veins in the rocks, that, of course, was a very difficult question. They would, he thought, have to look for an explanation to electrical agencies—to the electric currents which it was known passed through the earth—for, as a general rule, mineral veins had a certain bearing with regard to the rocks. Mr. Kendall gave a list of the

bearings of those he described, which agreed with many that occur in other mineral districts, such as that of Cornwall.

Mr. Dickinson said without tying himself down to all the views laid down by Mr. Kendall, he thought that gentleman's paper contained matter of great interest to the student, besides much that deserved the notice both of miners, geologists, and mineralogists. Of the deductions which Mr. Kendall drew, the first was scarcely to his mind sufficiently explicit, namely, that "veins are not filled fissures." Veins, whether they were filled fissures or not, were certainly fissures filled—with something. Mr. Kendall's second deduction was as to variations in breadth not being due to the slide of the rocks. He (the speaker) was disposed to agree with him that they were not due to that cause. The slide of the rock was distinctly marked on the sides not only of the mineral veins, but of every fault met with in the ground; and you may generally tell the throw of a fault by observing the direction in which the scales on the sides show the sliding to have taken place. Mr. Kendall, in his paper, expressed regret that so few persons should have written upon the subject. The name of Mr. Leithart, one of the oldest writers, who read a paper at the meeting of the British Association at Newcastle-on-Tyne so long ago as 1838, is omitted. The author, in that paper, went thoroughly into the subject, and the conclusion he arrived at was, that the filling up of the veins had been effected chiefly by means of electric currents through the strata. That such took place he (Mr. Dickinson) thought probable. The beautiful formation of crystals found occasionally in old workings confirmed it. As bearing upon this point, he called the attention of the members to a remarkable instance given in the Transactions for 1883 of the South Staffordshire and East Worcestershire Institute

of Mining Engineers, just published. It was in a paper contributed by Mr. H. Johnson, "on a specimen of a chemical growth upon a mineral."

Mr. STIRRUP, referring to the remarks of Mr. Dickinson upon crystallization in old coal mines, asked whether recent quartz crystals had been found.

Mr. DICKINSON replied that he had not known of quartz crystals; crystals of lime and iron pyrites are not unfrequently met with.

The PRESIDENT did not know of quartz crystals, but he had seen nodules of black quartz taken out of a coal seam.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XVIII. SESSION 1884-5.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 2nd day of December, 1884, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

The following gentlemen were balloted for, and duly elected ordinary members of the Society, namely :—

JOHN WHITEHEAD, Chorley, Lancashire.
HENRY CAMPBELL, Surveyor, St. Helens.
GEORGE ELCE, Altham Colliery, Accrington.
DAVID SHAW, Norbury Moor, near Stockport.

The following are the recent additions to the Library :—

Belfast Natural History and Philosophical Society: Report and Proceedings, 1883-84.—*From the Society.* Cornwall: Royal Institution of, Journal, Part II., Vol. VIII.—*From the Institution.* Dublin: Royal Dublin Society, Scientific Proceedings, Parts 6-7, Vol. III.; Parts 1-4, Vol. IV. Scientific Transactions, Vol. I., Series II., Nos. 20-24. Ditto, Vol. III., Series II., Nos. 1-3. Ditto, Part 25, Fossil Fishes of Carboniferous Limestone of Great Britain.—*From the Society.* Essex Field Club, Transactions, Part 8, Vol. III., and Report of the Council for 1883.—*From the Club.* Hertfordshire Natural History Society and Field Club, Parts 1-2, Vol. III.—*From the*

Club. Institution of Mechanical Engineers: Proceedings, No. 3 (Aug.), 1884.—*From the Institution*. Iron and Steel Institute, Journal, No. 1, 1884. —*From the Institute*. London: Geological Magazine, Nos. 244-245. Illustrated Science Monthly, Nos. 12-13, Vol. II. Geological Society, Quarterly Journal, No. 160, Vol. XL., November.—*From the Society*. Royal Society, Proceedings, No. 233, Vol. XXXVII.—*From the Society*. Royal Institution of Great Britain, Proceedings, No. 77, Vol. 10., Part 3. Manchester: Owen's College Calendar, 1884-5. Mining Institute of Scotland, Transactions, Part 5, Vol. VI.—*From the Institute*. Midland Institute of Engineers, Transactions, Part 74, Vol. IX.—*From the Institute*. North of England Institute of Engineers, Transactions, Part 4, Vol. XXXIII.—*From the Institute*. South Wales Institute of Engineers, Proceedings, No. 1, Vol. XIV.—*From the Institute*. Treatise on Ore Deposits, by J. Arthur Phillips.—*Purchased*. U.S.A.: Smithsonian Report for 1882.—*From the Board of Regents*. American Institute of Mining Engineers, Transactions, Vol. XII. (June, 1883, to February, 1884).—*From the Institute*. Washington: Mineral Resources of the United States, by Williams.—*From Director of U.S.A. Geological Survey*. Canadian Institute, Toronto, Proceedings, Fascs. No. 3, Vol. II., 1884.—*From the Institute*. Canadian Record of Science, Montreal, No. 1, Vol. I.—*From the Editor*. Sydney: Royal Society of New South Wales, Journal and Proceedings for 1883, Vol. XVII.—*From the Society*. Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft, Heft 2, Band 36, April to June, 1884. Brussels: Brochure sur La Feuille de Bilsen.—*From Author, E. Van den Broeck*. Dresden: Naturwissenschaftlichen Gesellschaft Isis in Dresden, Sitzungsberichte der, Jan. to June, 1884. Halle a/s Vereins für Erdkunde, Mittheilungen, 1884.—*From the Society*. Buenos Ayres: Resúmenes Generales y Preliminares del Censo Escolar Nacional, 1884, two copies.

Mr. STIRRUP (Hon. Sec.), having read the list of publications received since last meeting, called attention to an article which appeared in the French *Annales de Mines*, Part 1, 1884, on "The Coal Basin of Lancashire," by M. M. Luuyt. He had not had time to prepare an abstract of the article, but thought that those members who had assisted the author in his tour in this district might be interested to know of its existence.

The CHAIRMAN said that a system of procuring extracts of important foreign and other papers, to be published in

their transactions, would be a very useful practice. It is followed out by some kindred societies, and serves to bring valuable information before the members.

ON SOME DEPOSITS OF APATITE NEAR OTTAWA, CANADA.

By Professor W. Boyd Dawkins, M.A., F.R.S.

1. Description of Mines visited.

The Apatite Mines of Canada deserve more than a casual notice, not merely on account of their economic value, but because of the interesting facts which they yield, throwing light upon the history of mineral veins in general. It was my good fortune in September last to have visited, in company with the Bishop of Ontario and Messrs. Allan, Smith, McIntyre, and Grant,* some of those in the district of Buckingham and Portland, and the following communication to the Society is the result of my observations, combined with those published by Dr. Harrington in the *Report of the Geological Survey of Canada*, 1877-78.

The district to which it refers is that known as the North Ottawa Phosphate Region, and those parts of it which I have examined consist of a cluster of mines on the Rivière du Lièvre, about eighteen miles above Buckingham, a station on the Canadian Pacific Railway to the east of Ottawa.

On getting out of the train at Buckingham, a drive of four miles along a road almost impassable from the depth of the ruts, took us to a tiny wharf and we embarked in a little steam yacht, which swiftly carried us up a noble river, about

* I take this opportunity of thanking the three first of these gentlemen for their courtesy in arranging for me to visit the mines and to obtain specimens.

as broad as the Thames at Richmond, and flowing between bold rocky hills covered with trees glorious in the bright colours of autumn. We land and make our way along a track leading up to one of the wooded spurs, which showed as we left the river behind us, in the large blocks of vein stuff and mica lying in the ruts, that we were approaching the mines. The first vein which we examined is exposed in a shallow working at the outcrop and is filled with massive apatite containing bunches of black mica of the species known as phlogopite. The mine in work some three-quarters of a mile higher up is situated in a vein from twelve to fourteen feet wide (Fig. 1, No. 3, of the following list), and filled with various materials, apatite, mica, pyroxene, calc-spar, &c., the apatite varying in thickness from two to fourteen feet. The sides of the vein are in some parts clearly

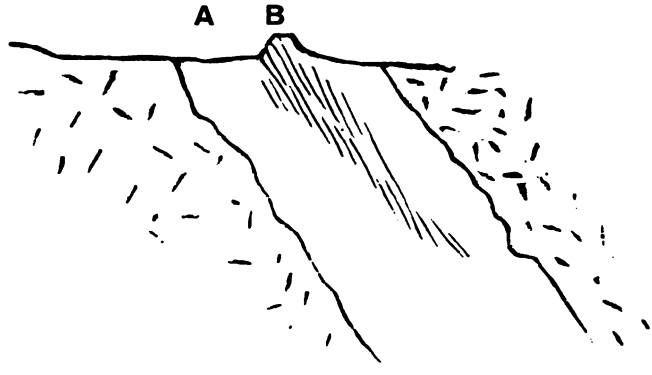


Fig. 1.
Mr. Allan's Mine, No. 3. of list.
A. Apatite and other minerals. B. Mica (Phlogopite).

defined from the surrounding rocks, while in others they shade off into the pyroxenite rock of the district. It is a true fissure vein with a hade of 57° to the East. The workings had been carried on to a depth of about 140 feet from the surface, a greater depth than any other similar mine in the country.

They were wet in some places, and the apatite was so decomposed as to take the form of pure sea-green sand, soft enough to be dug out. After examining the outcrop of another vein close by (No. 4 of the subjoined list) we visited the Emerald Mine, some two miles away, where open workings had been carried on on a large scale, and galleries had been driven to some distance into the rock. The vein here was from twelve to thirty feet thick, and filled with various minerals, among which apatite and calc-spar predominate. In Fig. 2 a portion of the vein is represented about thirty feet thick, as it appeared on our visit, one side of it being filled with massive apatite, and the rest with calc-spar, in which crystals of apatite, some of gigantic size, were scattered irregularly. Most of the largest and most perfect

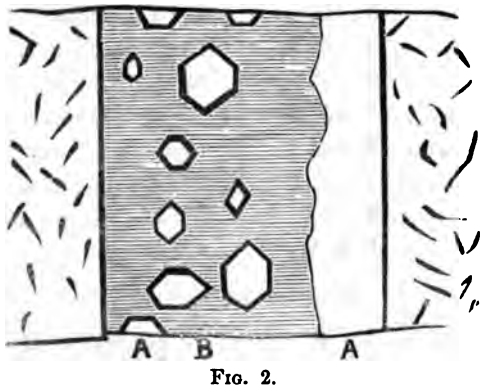


FIG. 2.
Apatite Vein in Emerald Mine.
A. Massive Apatite and Apatite Crystals.
B. Calc-spar.

crystals of apatite have been obtained from this mine, some weighing, as Mr. Allan informs me, as much as 1,000 lbs. In one place the vein is intersected by a dyke of igneous rock, probably of dolerite, which is of later age than the vein, since it fills a fault by which the vein has been dislocated.

2. The Direction of the Veins in the North Ottawa Phosphate Region.

The apatite veins which I examined, Nos. 3, 4, and 9 of the following list, do not agree in the direction of their strike or bearing, and when they are compared with others in the North Ottawa Phosphate Region described by Dr. Harrington in the Report above quoted, page 6, it will be seen that in the district generally they have no uniform direction. The predominant strikes are East and West, N.E., and N.W. by W.

Bearing of Apatite Veins in North Ottawa Phosphate Region.

1.	Portland..... N. 15° W.	10, 11, 12.	Templeton E. & W.
2.	Buckingham .. N. 45° E.	13.	Templeton.... N. 85°E.
3.	Portland..... N. 56° W.	14.	,, ... N. 78°E.
4.	,, ... N. 40° E.	15, 16.	,, ... N. 45°E.
5.	,, ... N. 55° W.	17, 18.	,, ... N. 35°E.
6.	,, ... N. 30° W.	19.	,, ... N. 17°E.
7.	,, ... N. 15° W.	20.	,, ... N. 67°W.
8.	,, ... N. 5° W.	21, 22.	,, ... N. 60°W.
9.	,, ... E. & W.	23, 24.	,, ... N. 40°W.

3. The Veinstuff.

The apatite occurs in the veins generally in a massive crystalline form, green, blue, or brown, and sometimes glassy, or granular. It also occurs as large independent crystals shooting from the side of the vein. Sometimes, as in the Emerald mine, the crystals are large, perfect at both ends, and completely enveloped in calc-spar. It contains, according to Mr. Hoffman's analysis, tribasic phosphate of lime, 85·241* to 89·810; fluoride of calcium, 5·860 to 7·929, besides other constituents, for which reference may

* The lower percentage, 74·241 of his analysis, No. 7, seems to be taken from an impure sample, and to be an exception to the rest of his results.

be made to the *Report of the Geological Survey of Canada*, 1877-8, p. 10 B. In comparison with European apatites it stands thus:—

Tribasic Phosphate of Lime,			Arendal, Norway	92·189
,,	,,	,,	Greiner, Tyrol	92·160
,,	,,	,,	Murcia, Spain	92·066
,,	,,	,,	Tokovaia, Ural	91·668
,,	,,	,,	Stüdianka, Russia	91·646
,,	,,	,,	Ottawa, mean of 7 analyses	87·521
,,	,,	,,	Estremadura, Spain, mean of 2 analyses	81·593
,,	,,	,,	Staffel, Nassau	75·273

It is, therefore, a high-class and valuable mineral, and, in my opinion, is one of the most important of the mineral resources of Canada.

The calc-spar is coarsely granular, white or flesh coloured, and intimately associated with the apatite, sometimes completely surrounding the crystals, and at others forming alternate layers. In some cases, as in the specimen on the table, it has a stalagmitic surface, and in others has been deposited along with quartz and other minerals in drusy cavities.

The mica, of the phlogopite species, and dark in colour, is also intimately associated with the apatite, sometimes being in large masses in the centre of the vein, or in others lining the sides of the vein, or coating the crystals of apatite. Among other minerals which I observed in the veinstuff were pyroxene, zinc-blende, and pyrite both in cubes and in octohedra. For further details as to the minerals associated with apatite, reference may be made to Dr. Harrington's admirable essay.

4. The Rocks Traversed by the Veins.

The rock (Pyroxenite of Hunt = Hypersthenite of Dana) traversed by the veins which I examined consists of a

bright crystalline and massive schist, composed to a large extent of pyroxene (augite), more or less altered, mica, orthoclase, triclinic felspar, and apatite. It contains, according to Dr. Harrington, subordinate layers of quartz. Were it not that it is bedded it would pass muster as an eruptive rock. Looking, however, at that fact, and the further consideration that it is associated with quartzites and altered limestones, it is, in my opinion, an altered rock belonging to the Archaian (Laurentian) series, which ranges over the vast region north of the Lakes, and of the St. Lawrence River, and which, according to Sir W. Dawson, is not less than 30,000 feet in thickness. In classification it goes with the Laurentian hornblendic gneisses. According to Dr. Harrington, both limestones and quartzites are traversed by veins of apatite in the North Ottawa Phosphate Region at Templeton, which I had no time to visit.

5. History of the Veins.

In dealing with the very much debated question as to the history of the apatite veins, the following points seem to me the most important:—

(*a*) The veins are in some cases sharply defined, and have evidently been deposited in a series of irregular fissures striking across the rock in various directions. (See Figs. 1 and 2.) Sometimes the vein-stuff shades off into the pyroxenite—as it might reasonably be expected to shade off on the hypothesis that the deposit took place under conditions of enormous heat and enormous pressure in the presence of water. These conditions are proved to have existed from the profound alteration of the associated Archaian rocks from the fragmental to the crystalline state.

(*b*) The character of the vein-stuff is such as is usually found in fissure-veins. In Fig. 3 it presents a banded structure, formed by alternate layers of apatite and

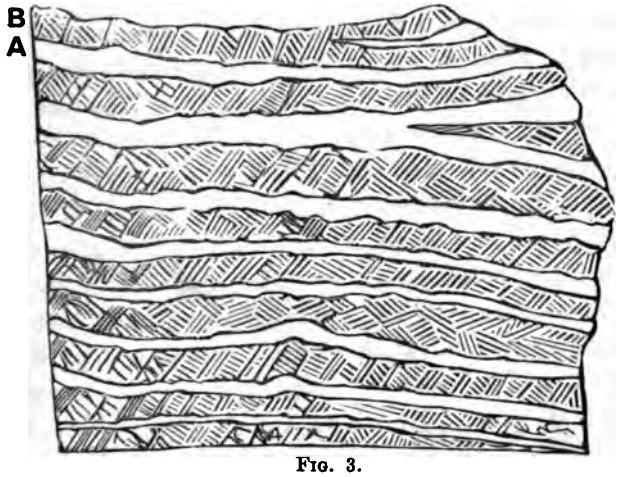


FIG. 3.
Vein stuff from No. 3, *nat. size*, Portland.
A. Apatite. B. Pyroxene.

pyroxene. In other cases layers of apatite and of a stalagmitic calcite alternate, and in one specimen on the table an angular fragment of quartzite is enveloped in vein-stuff composed of mica, pyroxene, and apatite. These two characters are found together, so far as I know, only in true fissure-veins, and are well known to practical workers in mineral veins generally.

(*c*) The apatite occurs disseminated through the pyroxenite rock in minute granules, and it is therefore argued that it has found its way into the veins by a mere process of segregation. It seems to me more probable that both rocks and veins have received their charge from some common deep-seated source by hydrothermal action, while both were sunk deep beneath the surface, and the heat and pressure were sufficient to allow of apatite and the other minerals in the vein being deposited by water.

(*d*) The surfaces of some of the crystals of apatite present traces of hydrothermal action in their rounded angles

and honeycombed surfaces, as in the specimens on the table. Solution might very well go on in one place while deposition was going on in another. The presence, too, of *perfect* crystals of apatite completely embedded in calc-spar, as in Fig. 2, can only be accounted for on the hypothesis that the vein was filled with a pasty mixture of apatite and calcite which allowed of the former developing a perfect crystalline form, the calc-spar matrix being sufficiently compact to keep the growing crystal from sinking to the bottom of the fissure. Had the fissure been empty the apatite crystals in this case, as in most others, would have been imperfect, and would spring from the side of the vein. This pasty condition of the vein-stuff is only explicable, in my belief, by hydrothermal or aqueo-igneous action.

(*e*) Nor are we without proof that the vein-stuff itself has been in a state of movement while it was in a pasty state in the crumpling and distortion to which the crystals of mica have been subjected. The specimens on the table have been obviously distorted by the movement of the surrounding matrix after their development as crystals.

From these facts it may be concluded that the veins of apatite in this district were formed in fissures in the Archaian rocks by hydrothermal or aqueo-igneous action under conditions of heat and pressure of the same general sort as that by which the rocks themselves have been affected, and by which the sandstones have been converted into quartzites, the muds and sandy clays into schists and crystalline rocks, and the limestones into crystalline calcite associated with serpentine.

These impressions of a hasty visit to the district in question are laid before the Society not merely because they relate to a large and rapidly developing mining industry in

Canada—the export last year being 14,478 tons, and the estimate for this being 23,000 tons—but because they are of local interest, since the products are largely used in Lancashire.

The following note relating to the physical characters of this important mineral, and the localities where it occurs in the British Isles, is added for the information of those who may seek for it:—"Apatite, crystalline phosphate of lime. Hexagonal, often hemihedral, occurs in six-sided prisms terminated by one or more planes, or the prism is terminated by a six-sided pyramid, and the lateral edges are sometimes replaced. Colours usually pale, and most commonly white, yellowish white, wine yellow, green, blue, or blueish green, and red, which are sometimes intermixed in the same crystal. Externally it is splendent; internally the lustre is shining and resinous, approaching to vitreous. Transparent to opaque: Brittle, cross fractures uneven, approaching to small conchoidal. Hardness, 5. Specific gravity, 3·25.

Blow-pipe.—Fusible with difficulty on the edges: with borax forms a clear globule, and in salt of phosphorus dissolves in great quantity, affording a transparent glass, which, when nearly saturated, becomes opaque on cooling, and presents crystalline faces."

Localities.—English: Cornwall, of a greyish-blue, at Stenna Gwynn, near St. Austell; St. Michael's Mount; Huel Kind, near St. Agnes; Fowey Consols and Huel France, near Tavistock. Cumberland, at the foot of Brandygill, Carrock Fells. Devonshire, at Bovey Tracey, in crystals sometimes two inches long, associated with black tourmaline.—*Scotch:* Dee side, in Aberdeenshire. *Irish:* Near Kilroot, Co. Antrim, in granite; near Hilltown, Dublin; and at Killiney Hill, in limestone." *Bristow's Glossary of Mineralogy.* It

has not as yet been discovered in paying quantities in the British Isles.

Mr. STIRRUP, in opening the discussion, said he felt personally exceedingly indebted to Professor Dawkins for his paper, which was one of extreme interest. The paper was valuable also from an economic point of view, for, as was well known, these deposits of phosphate were much sought after at the present time in consequence of their being used in the manufacture of chemical manures. We have in England phosphatic deposits, but none, that he knew of, at all like the one Professor Dawkins had described. The deposits of phosphate of lime in this country were found, as they all knew, in the Greensands and Tertiaries, and were worked pretty largely in the eastern counties of England. They differed in many respects, however, from the Canadian deposits, which were of extraordinary richness. The latter deposits were, in Professor Dawkins's view, formed by hydrothermal action. He (Mr. Stirrup) was of opinion that they must have been produced in other ways also, because there was a deposit which was worked in France, and which was formed in the Tertiary rocks, he believed—at all events in some recent rocks—and in connection with fossils of Eocene or even more recent type.

Professor DAWKINS: Might I explain? The deposit you are speaking about is phosphorite; it is not apatite. It is a deposit of lime; the apatite contains a per centage of fluor spar. The phosphorite deposits of France are a different thing altogether.

Mr. STIRRUP: I know that in M. Jannetaz's Book on Rocks the substance is called apatite. It does not, however, possess so high a per centage of phosphate as the Canadian apatite, having only about 45 per cent. against 87. But

this phosphate of lime is also, as is well known, the same mineral constituent that we find in bones of the mammalia, and having regard to that fact it is not unlikely that it may have been produced in other ways than by hydrothermal action from below. I do not believe in this theory of the deposit of such substances as we are speaking of, and that which was discussed at our last meeting, coming from some deep-seated source. I think there is an explanation which is much more intelligible, namely, that these phosphates of lime have been derived from the rocks themselves, or from the accumulation of bones of extinct animals, or even animals of recent date. I do not mean to say that the Canadian and all other apatites are of that character.

Mr. De Rance said he knew little of the subject, but had listened to Professor Dawkins's paper with interest. He had some slight notions of the method of occurrence of apatite in Spain, where some of his colleagues had been over reporting on it. It would appear from Professor Dawkins's paper that the area occupied by these deposits in North America must be considerable, and of great commercial importance. He did not hear that Professor Dawkins alluded to the origin of the phosphoric acid in these deposits. Mr. Stirrup, in his remarks, was speaking of another class of phosphate of lime. The impression he (Mr. De Rance) gathered from the paper was that Professor Dawkins thought that the phosphate of lime was derived from the interior of the earth through fissures in the earth's crust. On that point, probably, other members would be glad of further information.

The Chairman: The paper, I think, is of very great interest, and may be of practical value in directing geologists and miners in this country to possible sources of supply for this particular mineral. With that view I should like to have a somewhat fuller description of the rock which forms

has not as yet been discovered in paying quantities in the British Isles.

Mr. STIRRUP, in opening the discussion, said he felt personally exceedingly indebted to Professor Dawkins for his paper, which was one of extreme interest. The paper was valuable also from an economic point of view, for, as was well known, these deposits of phosphate were much sought after at the present time in consequence of their being used in the manufacture of chemical manures. We have in England phosphatic deposits, but none, that he knew of, at all like the one Professor Dawkins had described. The deposits of phosphate of lime in this country were found, as they all knew, in the Greensands and Tertiaries, and were worked pretty largely in the eastern counties of England. They differed in many respects, however, from the Canadian deposits, which were of extraordinary richness. The latter deposits were, in Professor Dawkins's view, formed by hydrothermal action. He (Mr. Stirrup) was of opinion that they must have been produced in other ways also, because there was a deposit which was worked in France, and which was formed in the Tertiary rocks, he believed—at all events in some recent rocks—and in connection with fossils of Eocene or even more recent type.

Professor DAWKINS: Might I explain? The deposit you are speaking about is phosphorite; it is not apatite. It is a deposit of lime; the apatite contains a per centage of fluor spar. The phosphorite deposits of France are a different thing altogether.

Mr. STIRRUP: I know that in M. Jannetaz's Book on Rocks the substance is called apatite. It does not, however, possess so high a per centage of phosphate as the Canadian apatite, having only about 45 per cent. against 87. But

this phosphate of lime is also, as is well known, the same mineral constituent that we find in bones of the mammalia, and having regard to that fact it is not unlikely that it may have been produced in other ways than by hydrothermal action from below. I do not believe in this theory of the deposit of such substances as we are speaking of, and that which was discussed at our last meeting, coming from some deep-seated source. I think there is an explanation which is much more intelligible, namely, that these phosphates of lime have been derived from the rocks themselves, or from the accumulation of bones of extinct animals, or even animals of recent date. I do not mean to say that the Canadian and all other apatites are of that character.

Mr. De Rance said he knew little of the subject, but had listened to Professor Dawkins's paper with interest. He had some slight notions of the method of occurrence of apatite in Spain, where some of his colleagues had been over reporting on it. It would appear from Professor Dawkins's paper that the area occupied by these deposits in North America must be considerable, and of great commercial importance. He did not hear that Professor Dawkins alluded to the origin of the phosphoric acid in these deposits. Mr. Stirrup, in his remarks, was speaking of another class of phosphate of lime. The impression he (Mr. De Rance) gathered from the paper was that Professor Dawkins thought that the phosphate of lime was derived from the interior of the earth through fissures in the earth's crust. On that point, probably, other members would be glad of further information.

The Chairman: The paper, I think, is of very great interest, and may be of practical value in directing geologists and miners in this country to possible sources of supply for this particular mineral. With that view I should like to have a somewhat fuller description of the rock which forms

the matrix, or the rock in which the veins containing the apatite occur, in Canada; for it seems the veins run through into other rocks but do not carry the apatite in those other rocks; it only occurs in this matrix of hornblende and gneiss.

Professor Boyd Dawkins: I am afraid I have not made myself intelligible to you. In the district I visited, the rocks consist of pyroxene, but in other districts where there are apatite mines they consist of quartzite and limestone.

The Chairman: They occur in the limestone as much as in the older rocks?

Professor Dawkins: Yes, as much as in the associated rocks.

The Chairman: Your naming the pyroxene only, reminded me of the rocks in the neighbourhood of the Lizard, where it extends to the limestone. There is another point of a practical kind I would like to ask about, that is, whether the per centage of lime is greater in the crystal than in the veins? Then, as to the value of the substance, can Professor Dawkins tell us what it sells at, at the mine? In the mineral statistics of this country we give, as nearly as we can ascertain it, the value of the mineral at the mine. I do not know whether it is worth while to go into any theory of the formation of the apatite, because where it is there it is—and that is the great thing. But the specimens Professor Dawkins has shown differ from the deposits in Sussex and Cambridge. From the presence of this large body of calc-spar—the fluate of lime—I should suppose that there has been some change from the fluate into the phosphate, by some action, rather than that the material has come from below.

Mr. BURNETT asked what was the formation in which the veins were found—was it silurian.

Professor DAWKINS: Archaian.

Professor DAWKINS, in replying to the observations which had been made, said: On the commercial question referred to by Mr. Dickinson he might say that the output of the Emerald Mine, when he was at Buckingham, was valued at something like 18 or 19 dollars per ton; the actual cost, of getting, ranged something between 5 and 6 dollars, so that there was a pretty good margin for somebody. With regard to the occurrence of apatite, so far as he knew, it occurred invariably in highly altered and crystalline rocks. Minute apatite crystals were quite a common constituent in many of the igneous rocks, but never under conditions such as were observed in Canada—that was, in veins. Wherever apatite veins had been met with, in Russia, Spain, Germany, and especially in Norway, it is invariably in the highly-altered rocks. The explanation of the origin of the vein-stuff—the origin, more especially of the apatite—was really one very difficult to frame. He could not see his way to accepting the current view that these veins had been filled with material derived altogether from the surrounding rocks, because the surrounding rocks did not in the first instance possess such a material as apatite—a combination of phosphate of lime with fluoride of calcium. The sand banks and the sandy mud banks forming the schists did not possess it, and still less was it an original constituent of the limestones. It seemed, therefore, quite reasonable to suppose that the crystals of apatite were introduced into the rocks in the same way as they were introduced into the mineral veins. If so, he should like to know where they came from, if not from below? There was not the slightest reason for supposing that they came from above; and he, for one, when he found veins

traversing rocks of widely different constitution was driven to suppose that they derived their existence from a source independent of all. The question as to the occurrence of crystals of apatite was an entirely different one from that of the ordinary phosphorite. He could not explain the presence of perfect crystals of apatite in a matrix of calc-spar, unless the calc-spar somehow or other prevented those crystals from descending to the bottom of the fissure or being perched on the sides of it. He did not know how such a process could have gone on unless the contents of the fissure were in a pasty condition due to the veins and rocks being at an enormous depth below the surface and subjected to hydrothermal action—an action which has left its marks on all the oldest rocks and especially on the archaian rocks. Rocks of that character were sparsely distributed in this country. They were to be found in the west of Cornwall, in Anglesey and Wales, and in the Highlands of Scotland—also in the Hebrides, but he did not anticipate any important phosphate deposits would be found in any of the older rocks in this country. It must be remembered that, even in the United States and Canada, these deposits were exceedingly local. The area covered by the Archaian rocks, in those regions, was a vast area, and the apatite deposits were scattered over it, occupying only an area relatively small. Crystals of apatite had been found in some of the iron mines of the United States, in ordinary veins. Whatever might be the source of apatite it seemed to him that it was to be looked upon as a mineral filling a vein exactly as the lead, silver, or gold in a metalliferous mine.

The further discussion was adjourned to a future meeting.

ON THE OCCURRENCE OF BRINE IN THE COAL MEASURES, WITH SOME REMARKS ON FILTRATION.

By C. E. De Rance, Assoc. Inst. C.E., F.G.S., F.R.G.S.

A notice of the occurrence of a brine spring in the coal measures of Durham occurs in the Philosophical Transactions for 1684, or exactly 200 years ago. Other springs have been described from time to time, and a recent paper communicated to the Geological Society of London, by Mr. Eunson, F.G.S., on the results obtained in the borings for water at Northampton, where the Carboniferous rocks with brine springs have been discovered, instead of the looked for Triassic sandstones with stores of good water.

It is a matter of interest to ascertain how far the Carboniferous brines compare in character with those of the Keuper marls, and with ordinary mineral saline springs. The following notes do not offer by any means an exhaustive account of the subject, but may form the foundation for such an inquiry, which has an interest beyond that of the mere occurrence of brine, in the fact that the sandstones of the Coal Measures of many districts, like the millstone grits beneath them, are valuable water-bearing rocks, storing large volumes of water, and rendering it up in a condition of great purity; and should it appear that brine springs are of common occurrence throughout the coal measures, it would render that class of rocks open to suspicion, for waterworks purposes, which would be a matter of regret at the present time, when the available sources of supply left to us are so few, and the effect of a few months' drought in bringing about a failure of a large number of gravitation waterworks in the North of England is so

marked. The recently reported case of large volumes of water of good quality being met with in the Moston Colliery, near this city, is a case in point, if such waters should prove to be derived from the Coal Measures, showing the quantity and quality of water often yielded by these measures, and which, though somewhat uncommon in the Lancashire coal-field, are so well known in that of Yorkshire.

In order to have some standard of comparison of the various brines of which I have been able to collect information, I would quote an analysis made by Mr. Norman Tate, F.C.S., for my friend, Mr. I. Roberts, F.G.S., of Liverpool, of the water of half-tide ebb, at St. George's Pier, Liverpool, and place by it, for comparison, an analysis made by Mr. Phillips, of London, in 1850, of brackish water from a well in Great Howard Street, Liverpool, near the Landing Stage.

	River Mersey. Grains, per gal.		Gt. Howard-St. Grains.
Chloride of Sodium.....	1295·50	....	531·00
„ „ Potassium.....	5·32	....	trace
„ „ Magnesium	85·60	....	209·00
Sulphate of Magnesia.....	113·14	....	—
„ „ Lime	56·44	....	144·00
Carbonate of Magnesia	0·80	....	—
„ „ Lime	0·64	....	28·70
Silica.....	0·64	....	0·32
Alkaline Nitrate	trace	....	—
Iodine and Bromide, trace ..	trace	....	—
Organic matter and loss	not det.	....	1·30
Total solid matter....	1558·08		914·32

Durham:—The earliest notice of brine in the Coal-Measures is that already referred to of a salt spring issuing near the river Wear, near Butterby (described in the Philosophical Transactions for 1684, p. 726, by H. Todd).

In 1794, a spring described "as salter than the sea" was discovered at Birtley Colliery, and yielded 26,400 gallons per day.

Salt springs were described by Hutton (Transactions, Newcastle Natural History, Vol. I., p. 71) at Walker, St. Lawrence, Wallsend, Hepburn, Lambton, and Percy Main Collieries.

Messrs. Daglish & Foster describe (Trans. of N. of England Inst. Eng., Vol. XIII., p. 208) a brine spring at Seaton Colliery, almost as dense as sea-water, issuing from the roof of the Hutton seam.

Yorkshire :—Professor Green (Mem. Geol. Sur. Yorkshire Coalfield) describes the large quantities of water met with in penetrating the Oakenshaw rock and other well-known Coal-Measure sandstones, but I do not find any reference to brine-springs; but the Woolley Edge rock, east of Wakefield, he states is locally called the "bleeding rock" from its containing acrid water that blisters the hands of the sinkers. This appears to be very exceptionable, and the quality of the water generally met with exceedingly good. The Oaks rock at Wath Main, 55 yards in thickness, yielded the enormous quantity of 3,000 gallons of water per minute, and after the tubbing was in the shaft, but before it was fully wedged, the yield for months being 18,000 gallons per minute. It was at one time proposed to supply Wakefield from this source.

Lancashire :—Salt springs occur at Robin Hood Well and Salt Pit Houses, in Charnock Richard, west of Chorley. They were noted by the Ordnance 6-inch Survey, and still flowed at the time of my survey in 1869. They are evidently derived from the Coal Measures occurring close to the fault bringing in the Upper Mottled sandstone.

Further south, at Worthington Colliery, near Standish, I was informed by the late Mr. Thompson, M.E., a strong spring of brine was met with.

More recently, a detailed analysis, made by Mr. John Collins, F.C.S., of Bolton, for Mr. G. H. Daglish, C.E., of St-Helens, has been kindly furnished me by the former, of a brine obtained at Rose Bridge Colliery, in which the total chlorides amounted to 3514 grains to the gallon. The very remarkable feature in this analysis is the quantity of chloride of potash, which amounted to no less than 602 grains per gallon. In the Cheshire (Keuper marl) brine and rock salt, potash salts are present, as was noticed by E. W. Brayley, in 1829 (Philosophical Transactions, Sec. 2, Vol. V., p. 411), but the quantity is very small.

Analysis of a sample of water from Rose Bridge Colliery, Wigan.

	Grs. per Gall.		Grs. per Gall.	Parts per 100,000
Sodium Chloride	2606·021			
Magnesium Chloride.	306·298	Chlorides	3514·380 =	5020·54
Potassic Chloride....	602·061			
Sodium Sulphate	102·026			
Calcic Sulphate	106·612	Sulphates	290·702 =	415·28
Potassic Sulphate....	82·064			
Sodium Bromide	36·024	Bromides	65·626 =	93·75
Magnesium Bromide.	29·602			
Magnesium Carbonate	33·064	Carbonates....	124·085 =	177·26
Calcic Carbonate	91·021			
Iron Peroxide	Traces.			
Silica Acid and Loss.	94·007			
Total Saline Matters.	4088·800	(Organic Matter, Traces only).		

Cheshire.—At the Dunkirk Coal Company's Astley Deep Pit, at Dukinfield, Mr. Charlton describes (*Geologist*, vol. iv., p. 398) a brine spring issuing from a fissure, yielding 300 gallons in 24 hours, containing 3,591 grains of chloride, chiefly soda, which compares well, as to total chlorides, with the Rose Bridge example.

The following is the analysis given :—

	Grains in 100 grains of brine.		Equivalent to grs. per gallon.
Chloride of Sodium	4·50	.....	3150·0
Chloride of Calcium	0·37	.....	259·0
Chloride of Magnesium..	0·26	.....	182·0
	5·13		3591·0

Here the chloride of potash appears to be absent, and it differs in the presence of a considerable portion of chloride of calcium, and in having a large quantity of chloride of sodium.

Flintshire.—In 1882 I examined the colliery workings at Mostyn, under the estuary of the Dee, which extend half a mile from the shafts, and found a considerable volume of water coming in from above, flowing in a definite channel. To the taste it was apparently much salter than the water of the Dee at high tide. The sea has broken into this colliery during the present year, as I anticipated it would, from the removal of the "pillars" too near the bed of the estuary, but I think the water met with previously was derived from the land.

In *Leicestershire*, a salt spring issues at the surface of the ground at Donnisthorpe.*

At the Moira Colliery, the late Mr. Wm. Molyneux, F.G.S., described a strong spring of brine, as occurring in the Moira Main Colliery.†

* Mammatt's "Geological Facts," p. 35.

† Report British Association, 1877.

The following is the analysis of the brine from the Moira Main Colliery, made by Dr. Ure in 1834 :—

	Grs. per Gallon.
Chloride of Sodium	3700·5
„ Magnesium	16·0
„ Potassium	Trace.
„ Calcium	851·2
Bromides of Potassium and Magnesium...	8·0
Soda, as a Protochloride	Trace.
	4575·7

The above 8 grs. of bromides are equal to 6 grs. of Bromine.

Northamptonshire.—At Kingsthorpe, 2½ miles north-east of Northampton, a trial for coal was made in 1830, against the advice of Dr. William Smith, F.R.S., and Mr. Richardson, of the British Museum. This shaft was described by Dr. Buckland, and later by the late Mr. S. Sharp (*Geol. Mag.*, vol. viii.) It passed through 120 feet of Oolites, 760 feet of Lias, and 60 feet of sandstone, 12 feet of marls, and 15 feet of conglomerates, referred at the time by Dr. Smith, to the New Red series. The Middle Lias (or marlstone) appears to have produced 36,000 gallons per hour at a depth of 210 feet from the surface, and the New Red a like quantity of brackish water from a depth of 880 feet. The work was stopped at 967 feet, after costing £30,000.

In 1846 the London and North-Western Railway bored for water in Northampton, and, on reaching 650 feet, tapped a salt-water spring, containing chloride of sodium, carbonate of soda, sulphates of magnesia and lime, the spring occurring in a 4-foot bed of magnesian limestone, lying under 50 feet of variegated sandstone and marls.

In 1879 a boring was made by the Water Company at Kettering Road, one mile north-east of Northampton, to a depth of 851 feet. In this boring the Lias, rested on an eroded surface of crystalline conglomerates and sandstone, 67½ feet in thickness, which are somewhat doubtful in age, no fossils having been discovered, but overlie 45 feet of carboniferous dolomitic limestone with fossils, which is believed to have yielded the 200,000 gallons of saline water met with in this boring, containing 1200 grains of mineral salts per gallon.

The second trial of the Northampton Waterworks Company was at Gayton, two miles north-west of Blisworth Station, and five south-west of Northampton. The details are given by Mr. H. J. Eunson ("Range of the Palæozoic Rocks beneath Northampton," Q. J. G. S., vol. xl., part 3, p. 485). The Lias, White Lias, and Rhætic continued to 617 feet from the surface, the latter resting on a slightly eroded series of marl, followed by variegated sandstone 60 feet in thickness, which are referred to the trias. At 676½ feet occurred carboniferous sandstone with fossil, which, with the underlying marls and limestone, are regarded as a local littoral deposit, lying on the true carboniferous limestone occurring at 699 feet. The beds beneath are very remarkable, but do not affect the present inquiry. The total depth reached was 994 feet. As in the other boring, the water was saline, containing 1500 grains of mineral salts to the gallon, the quantity being only 100,000 gallons per day. The water stood 20 feet higher than at Kettering Road, giving a gradient ($\frac{1}{80}$) of 3⅓ feet per mile to the north-east.

In the boring lately carried out for Mr. J. Fleming (of Newcastle-on-Tyne), at Orton, five miles West of Kettering, and twelve miles to the N.E. of Northampton, the Triassic beds were absent, and the beds of doubtful age were 24 feet, the underlying Carboniferous beds were absent, and a quartz-

felsite, 74 feet thick, still persisted when the boring was abandoned at 789 feet.

Somersetshire.—Much information was collected by the late Mr. Moore, F.G.S., in 1874-75, as to the water-bearing properties of the Bristol, Bath, and Radstock coalfields, forming part of the enquiry into the Circulation of Underground Waters, instituted by the British Association. At Braysdown Colliery, which is 500 yards in depth, a constant volume of water had to be daily pumped, which yielded 1,008 grains of chloride of sodium per gallon, according to the analysis of Mr. Biggs.

At Tiverton Colliery, near Bath, a spring was met with at 72 feet from the surface, yielding 16,800 gallons of water every 24 hours, and was found to contain, on analysis by Mr. Ekin, F.C.S., of Bath, 78·96 grains per gallon, but the water is stated to be distinctly derived from the Lower Lias.

At Bristol, the wells vary in depth from 60 to 300 feet, and are situated at heights of from 10 to 200 feet above the sea; in some cases the water is brackish and is stated by Mr. Stoddart, F.G.S., to be derived from the Red Marls, and partly from the Coal Measures, and he states that some of the wells are reached by tidal-water.

Brine in the Permian.—The thick deposits of rock-salt, discovered at the mouth of the Tees, occurred at a depth of 1206 feet from the surface, and continued to 1306 feet, at Messrs. Bolckow and Vaughan's, Middlesboro'; at Messrs. Bell Bros., Saltholm Farm, Durham, it occurred at 1117 feet from the surface, and continued to 1355 feet. The following analysis is given* of the rock salt from the first boring:—

* Trans. N. of Eng. I. M. E., Vol. xii, p. 10.

Chloride of Sodium	96·63	Oxide of Lithium . .	.06
Sulphate of Calcium	3·09	Oxide of Iron	trace
Sulphate Magnesium	·08	Water	0·4
Sulphate of Sodium	·10		

BRINE IN THE NEW RED SANDSTONE.—The Underground Water Committee of the British Association, of which I have been secretary since its formation in 1874, has circulated several thousand forms of enquiry to elicit information as to wells and borings, *query 13* asks "if any salt springs were passed through in sinking the well?" and *query 14*, whether there "are any salt springs in its district?" and it is worthy of note how exceedingly few wells have intercepted any brine in the New Red Sandstone.

Lancashire :—One of the most marked exceptions to this rule was the water obtained by Mr. Beck, at the Dallam Lane Forge boring, which I have already described to the Society, in which 4,500 grains of chlorides were present to the gallon, and I then suggested, from several considerations, that these salts were derived from the Coal Measures, which had been proved to be much nearer the surface in the Warrington district than was formerly supposed. It is of interest to observe that William Smith, the Father of English Geology, and afterwards Sir Charles Lyell, suggested that the saline waters of Bath were derived from the Coal Measures underlying the later rocks of that city.

At Ordsal Lane, a shaft and boring was carried to a depth of 460 feet, from which 717,120 gallons per day were pumped for 12 months, which was very brackish. Subsequently this bore-hole was deepened to 1,500 feet, the Coal Measures being reached at 860 feet from the surface. It is probable that in this case also the saline water was derived from the Coal Measures.

Cheshire :—Brine springs are described as being worked to a small extent at Aldersey Hall, by Ormerod (in Q. J. G. S., vol. iv., p. 262), and as issuing from drift-clay and sand. These drift deposits overlie the Lower Mottled Sandstone, but the springs may be derived from the Coal Measures beneath.

Lincolnshire :—Mr. Dickinson describes* a boring 1140 feet in depth put down west of Horncastle, at a point situated on the Kimeridge clay, near the base of the Cretaceous rocks. This bore-hole is stated to have penetrated the New Red Sandstone for some distance, and to have proved a valuable brine spring. The details of this boring would be very interesting. It is obvious that to reach the Triassic sandstone, the Kimeridge clay, the various oolitic beds, the Lias and the Keuper marls would have to be penetrated. At Scarle, which is nearer the outcrop, a boring described† by Professor Hull, F.R.S., proved the Keuper marls to be about 600 feet thick, and the overlying Rhætic 65 feet, while a boring at Stamford, made by the late Marquis of Exeter in a futile search for coal, commenced in a similar geological horizon to Horncastle, failed to reach the base of the Lias at 500 feet. Supposing it, however, to have been close at hand when the boring was discontinued, and adding these figures together, they come to 1,165 feet, a figure but little differing from the depth of the Horncastle boring described by Mr. Dickinson, which supports his identification of the lower beds, belonging to the New Red Sandstone.

Brine in the Keuper Marls.—In the Cheshire salt district, the brine generally contains 25 per cent. of chloride of sodium, or 2½ lbs. of salt to the gallon; there being 896

* Report of H.M. Inspector of Mines, 1881.

† On a deep boring for Coal, at Scarle. Proc. Inst., C.E., Vol. xlix., 1877.

"two-and-a-half pounds in a ton, each ton of white salt manufactured requires the pumping 896 gallons of brine, which, at the present rate of manufacture, necessitates the daily pumping of about 6 million gallons of salt water. Part of this quantity as at Northwich is due to allowing fresh water artificially to come into contact with rock salt, in the Winsford, Middlewich, and Sandbach districts it is derived from the natural absorption of rainfall; but so far as the latter is concerned, the limits of production have been reached, as the head of brine has gradually fallen, so that at Winsford it will not rise above the "rock-head."

The following analyses are interesting, as showing the composition of the rock salt, which dissolved forms the Cheshire brine.

	Northwich, by Mr. Henry. (Mr. Bristow's Glossary of Mineralogy.)	Marston Mine, by Prof. Crace Calvert 1871. (Mr. Dickinson, Report, Inspec. of Mines, 1881.)
Chloride of Sodium	98·32	96·70
Chloride of Calcium	0·01	0·68
Chloride of Magnesium..	0·62	trace
Sulphate of Lime	0·65	0·25
Water.....	—	0·63
Insoluble Matter	1·00	1·74
	100·00	100·00

The most transparent portions of the crystals of rock salt consist of pure chloride of sodium, the less transparent portions contain the earthy salts which occur in the brine, and which were detected by Dr. Holland in 1808, which he found to vary from 0·625 to 2·500 per cent.

Analysis of Cheshire and Worcestershire Brine, extracted from Richardson and Watts's "Chemistry as applied to Arts and Manufactures," Vol. I., Part 3.

Constituents in 100 parts Brine.	Cheshire.		Worcestershire.	
	Marston.	Wheelock.	Droitwich.	Stoke.
Chloride of sodium	25·222 (17655·40)	25·333	22·452	25·492
,, ,, potassium	—	—	trace	—
Bromide of sodium	·011 (7·70)	·020	trace	trace
Iodide of sodium	trace	trace	trace	trace
Chloride of magnesium	—	·171	—	—
Sulphate of potash	trace	trace	trace	trace
Sulphate of soda	·146 (102·20)	—	·390	·594
Sulphate of magnesia	—	—	—	—
Sulphate of lime	·391 (273·20)	·418	·387	·261
Carbonate of soda	·036 (25·20)	—	·115	·016
,, ,, magnesia	·107 (74·90)	·107	·034	·034
,, ,, manganese	trace	trace	—	—
,, ,, lime	trace	trace	trace	trace
Phosphate of lime	trace	trace	trace	trace
,, ,, ferric oxide	trace	trace	trace	trace
Aluminia	trace	trace	—	—
Silica	—	—	trace	trace
	25·913 (18139·10)	26·049	23·378	26·397

(Figures in a parenthesis are calculated equivalent grains per gallon.)

Midland Counties.—Referring again to the Rose Bridge brine analysis, the quantity of sulphate of soda compares with the quantity present at the Cheltenham springs, and a spring at Swindon, the former were believed by Sir Roderick Murchison to rise through the overlying Lias from the Keuper

Marls, and to indicate the persistency of the rock-salt deposit, in which he was supported by Professor Hull, F.R.S., who also drew attention to the brine discovered at Rugby in the Marls, at a depth of 1,141 feet from the surface, and 663 feet below the Lias, which was penetrated in a hopeless search for fresh water.

To the Keuper Marls also may be ascribed the origin, of the weak brine and rock-salt discovered in the fruitless search for water, made by the Stafford Corporation in a boring on Stafford Common, which, after passing through 14 feet of sand and gravel, was carried to a depth of 770 feet without proving the base of the Marls. [Mr. Dickinson, in Reports of H.M. Inspector of Mines, 1881.]

Mineral Springs.—In the following table, the analysis of the Mersey sea water is grouped together with the analysis of brine from Rose Bridge, Dukinfield, and Moira Collieries, and those of six saline springs in England, and five saline springs on the Continent.

Taking the quantity of *chlorides* in the sea water at Liverpool as unity, and comparing them with the 14 other analyses given, it will be seen that all the mineral springs of England and the Continent contain considerably less than sea water, Kissingen springs coming the nearest to full strength, while Bath water contains of chloride only $\frac{1}{4}$th part of unity.

Taking the total salts in the Mersey water as unity, it is not reached by any English saline spring, the nearest to the full strength being the remarkable spring at St. Clement's, Oxford, described* by Professor Prestwich, F.R.S. By the foreign springs they are exceeded, by the Friederichshall and Seidletz waters, which are slightly salter.

* "On the Mineral Water discovered at St. Clement's," read at the Ashmolean Society, June 12, 1876.

Columns 5 to 14 are from Professor Prestwich's paper on St. Clement's spring.	1 Half-Ebb Water River Mersey, Liverpool.	2 Rose Bridge Colliery, Wigan.	3 Dukinfield Colliery, Cheshire.	4 Moira Main Coal,* Leicester.	5 Oxford, St. Clements.	6 Cheltenham. Royal Old Well.	6a Cheltenham. Pit Ville.	7 Leamington, Bath Street Well.	8 Swindon, Purton Spring.	9 Bath, King's Bath.	10 Germany and France. Friederichshall Saxe Miningen.	11 Germany and France. Kissingen, Bavaria, (the Soolensprudd).	12 Germany and France. Rehm Westphalia Soole Spring.	13 Germany and France. Mezierbs, France.	14 Germany and France. Sledlitz, Bohemia.
Chloride of Sodium	1295·50	2606·021	3150·00	3700·50	748·30	590·33	*481·19	476·96	34·30	12·64	546·00	997·9	245·00	326·90	....
,, ,, Magnesium	85·60	306·298	182·00	16·00	27·23	8·00	....	115·44	....	14·58	289·00	222·6	140·00	75·18	....
,, ,, Potassium	5·32	602·061	....	trace	....	....	....	....	....	....	....	....	....	....	....
,, ,, Calcium	....	....	259·00	851·20	....	....	....	78·00	....	....	....	....	70·00	....	....
Sulphate of Soda	....	102·026	....	....	357·63	94·94	*115·82	68·72	*114·15	*23·87	511·00	227·5	525·00	203·98	51·10
,, ,, Potassium	....	82·064	....	....	....	....	....	....	trace	trace	....	....	....	....	....
,, ,, Magnesia	113·14	....	....	....	....	....	....	....	77·20	....	287·00	....	175·00	....	2027·40
,, ,, Lime	56·44	106·612	....	....	135·37	....	....	190·00	83·87	80·05	7·00	....	....	55·16	40·70
Carbonate of Soda	....	....	....	....	....	....	20·15	....	*28·88	....	50·40	....	....	....	....
,, ,, Magnesia	0·80	33·064	....	....	....	6·80	11·39	....	....	0·33	....	58·8	35·00	....	10·00
,, ,, Lime	0·64	91·021	....	....	7·63	17·06	7·70	....	....	8·82	18·20	....	210·00	31·92	15·40
Iodide or Bromide of Sodium	trace	36·024	....	8·00	trace	3·50	3·29	trace	0·16	....	1·40	trace	....	....	....
Iron	....	trace	....	trace	trace	....	....	trace	0·28	1·07	trace	2·8	....	....	....
Silica (and loss in Solution)	0·64	94·021	....	....	1·26	2·75	2·77	trace	1·28	2·98	35·50	trace	....	....	....
Organic and Extractive matter	....	....	....	....	0·10	18·39	3·85	....	8·75	....	2·80	....	....	....	5·90
	1558·08	4088·800	3591·00	4575·70	1277·52	741·77	646·16	929·12	348·87	144·34	1749·50	1489·6	1400·00	693·14	2350·50

No. 1.—Norman Tate.
,, 2.—John Collins.
,, 3.—Mr. Charlton.
,, 4.—Dr. Ure.
,, 5.—Donkin.
No. 6.—Abel & Rowney, 1848.
,, 7.—Anon., 1873.
,, 8.—Voelcker, 1861.
,, 9.—Meek & Galloway, 1846.
,, 10.—O. Henry (Pelouze & Frency, 1854).
No. 11.—Constatine James Liebig.
,, 12.—Sutro Bischoff.
,, 13.—Wahart-Duhesme (Annuaire des Eaux, 1854).
,, 14.—Bouillon & Lagrange (Althaus).

* Potash Salts included with Soda Salts, are marked with an asterisk.

Omitting Bath, which only contains 144 grains to the gallon, it may be stated that the mineral springs contain of saline contents from 349 to 2,350 grains per gallon, and that they average about 1,100 grains to the gallon, or less than the total salts of the moderately salt sea water, of the Liverpool Landing Stage.

Most of the springs tabulated are derived from Artesian wells or borings, Mezières and Rehm through the Lias into the Trias, Leamington from the Trias, Cheltenham through the Lias probably to the Trias, to which source also Professor Prestwich ascribes the St. Clement's spring, the Oolites resting, he believes, directly on the Trias. The springs at Friederichshall are derived from the Trias also, but those of Seidlitz are stated by Professor Prestwich to be in Basaltic rock.

Comparing these results with the brine of the Keuper Marls, it will be noticed that sea water, the Coal Measure brines, and all the springs, could absorb a much larger proportion of saline materials than they are actually found to contain. The Keuper Marl brine, on the contrary, is full strength, containing 25 per cent. of its weight of salts, and sometimes more, being a supersaturated solution.

In conclusion it may be stated that Coal-Measure brines appear to average about 4,000 grains to the gallon of total saline contents, or about 2½ times as much as the water of half-tide at Liverpool, while the average saline contents of the mineral springs, of saline character, is about 1,100 grains, or less than the moderately salt sea water of Liverpool, while brine from the Keuper Marls, contain a quarter of its weight of chloride of sodium, as well as other salts, or about 17,500 grains to the gallon, being eleven times salter than the sea at Liverpool; the Coal-Measure brine springs consequently occupy an intermediate place between the mineral springs and the Keuper brine.

The brackish waters occurring in the Northamptonshire borings, fall naturally rather into the mineral spring group, than with the Coal-Measure brines.

The presence of brine of Coal-Measure origin has only effected wells and pumping stations made for the object of water supply in a very few instances, but they are sufficiently numerous to render great care necessary in the selection of pumping stations in these rocks, where nothing is already known of the character of the water which will be yielded.

The great Keuper salt deposits were formed, in a series of rocks, in the lower portion of which Labyrinthodont foot-prints occur. It is worthy of note that these conditions were foreshadowed in the Coal-Measures of the Kilkenny coal-field, where in beds of marls filling up channels beneath the fireclay underlying the "Kilkenny four-feet coal," occurred the Labyrinthodont remains described by Professor Huxley, P.R.S., and it is possible that occasional crystals of rock-salt occur in such situations, but it is highly improbable that they should do so in the thick sandstone occurring in the Yorkshire coalfields, and to a less extent in the Lancashire area.

Filtration.—Before closing this paper, I would offer some remarks on this cognate subject. From the analysis of the Mersey water, and that of the water of the neighbouring wells, and from subsequent detailed experiments, into the action of cubes of sandstone, in arresting and holding (as was supposed) a portion of the chlorides, in saline solutions allowed to filter through them, my friend Mr. I. Roberts, F.G.S., came to the conclusion that the water in the wells near the river is gradually becoming salter, owing to the filtering power of the sandstone being limited, and he considered it withdrew salts from the

water passing through it by a mechanical or molecular process, and not the result of any chemical action. He thought the capillary attraction of the grains of sand of which the rock-mass is composed, is most powerful for the sodium, calcium, and magnesium chlorides than it is for the water of solution, and that these therefore are retained in the stone when the water of solution filters out. [Experiment on the Filtration of Sea-water through Triassic Sandstone, British Assoc. Report, 1878.]

Doubt has been lately thrown on these deductions by Mr. Wm. Ripley Nichols, Member of the Boston (U.S.) Society of Engineers (On the filtration of certain saline solutions through sand, Boston, 1884), who has been investigating the subject for some years. Mr. Nichols' investigations render it almost certain that had the blocks of sandstone experimented on been thoroughly *dry* the result noticed by Mr. Roberts would not have occurred, but what really took place was, that the salt solution drove before it water which was already contained in the pores of the rock, and mixed with it but little. Mr.Nichols repeated the experiment with Ohio sandstones in a wet and in dry condition. In the former the first filtrates were less saline than the subsequent; in the latter they were actually salter, owing to their being a small quantity of soluble chloride already contained in the rock.

Well-water near tidal rivers and the sea, that gradually increase in hardness, must therefore be due to increased consumption, causing the "concentric circle of supply" around the "cone of exhaustion" to reach the bed of the Mersey, which there consists of red sandstone.

Mr. Wethered, F.G.S., obtained from Mr. Lott, of the Chelsea Waterworks, the following section of the filter beds there:—

	Ft.	In.	
1. Fine sand	3	6	From Thames, cleansed by hose.
2. Shells	0	4	To separate 1 from 2.
3. Shingle	2	0	Increased in coarseness, to prevent pipes being clogged.
4. Coarse shingle	2	2	
	8	2	

Mr. Wethered gives* chemical analysis of the sand bed that does the work, and compares it with the mean of five analyses of Millstone Grit :—

	Filter Bed sand.	Bristol District. Millstone Grit.	Pennant Grit. Bristol.
Silica	90·05	97·80	84·96
Alumina.....	·40	·47	4·34
Oxide of iron.....	6·90	·80	4·55
Lime	—	·44	1·29
Carbonaceous matter	·70	·17	2·86
Carbonic acid.....	1·50	·39	1·33
Magnesia	·01	—	·05
Alkalies	trace	—	—
Moisture.....	·26	·22	·58
	99·97	100·29	99·96

The rate of filtration at the Chelsea Works is two gallons per hour,† and Mr. Wethered points out that the process which the London Water Companies are carrying out artificially is that which is naturally going on in the rocks, there being nothing in the chemical composition of the Millstone or Pennant Grits, or in the filter bed, which can oxidize the organic impurity of water. Any cleansing process induced must be mechanical, and the oxidation, causing the riddance of organic contamination, due to the oxygen of the air lodging between the grains of the sand or rock. One cubic foot of Inferior Oolite, capable of

* Eighth report Underground Water Committee, Brit. Assoc. Report for 1882.

† Report on the London Water Companies, by Colonel Bolton, Feb. 1882.

absorbing one gallon of water, when deprived of that water, absorbing 0·16 of its volume of air.

The "Clark process" of softening water causes several distinct chemical changes in the condition of the water treated. At Horsham Waterworks the water was so highly charged with iron that everything it touched was discoloured, but Mr. Baldwin Latham, M.I.C.E., found* by the application of lime the whole of the iron was removed.

An experiment was made in 1851, by the Chelsea Waterworks Company, on the effect of the lime process, and it was found that with the River Thames in good condition, and the mixing taking ten hours, the hardness was reduced from 14·0 to 4·5; with the river in flood the hardness was 16·5, reduced to 5·0, but the yellow tinge remained. In other experiments it has been found that softening process never clears any suspended matter giving it a tint, and that it is desirable to filter it until bright, before treating it.

The results of the Rivers Pollution Commission analyses, and those published by Professor Wanklyn, show that the Clark process has a marked effect in diminishing the quantity of albuminoid ammonia.

Whilst on the subject of filtration I would wish to call attention to the "Revolver" lately applied to the Antwerp Waterworks.† The water used for the supply of that city is heavily charged with sediment, and contains a very large amount of organic impurity. To effect the necessary purification for domestic supply, filters of Bischof's spongy iron were used; these succeeded, but were found to be exceedingly costly, and when, in the autumn of 1883, Mr. W. Anderson, M.Inst.C.E., was called in to carry out the necessary extension of the works, he felt some other means must be tried. Dr.

* Water Congress. Jour. Soc. Arts, July, 1884.

† Water Congress, Jour. Soc. of Arts, July, 1884.

Bischof having stated that it was necessary for the spongy iron to be in actual contact with the water for 45 minutes, some hesitation had been felt in applying a suggestion of Sir Frederick Abel, C.B., F.R.S., made some time previously, that the iron should be made to cleanse itself, by rubbing continually against itself.

To carry this out, a revolving cylinder, 4ft. 6in. diameter, and 5ft. 6in. long, fitted with inlet and outlet pipes, and with shelves or ledges for scooping up the iron, raising it to the top of the cylinder, and then letting it fall through the water. Twelve gallons per minute was first run through, which gave a contact of 45 minutes, as recommended by Dr. Bischof; the water was heavily charged with iron, and the flow was increased to thirty gallons, which still dissolved 1·20 grains of iron per gallon, or twelve times as much as the Antwerp experience showed to be necessary; the flow was then increased to 60 gallons per minute, and even then 0·90 grain per gallon was dissolved.

The revolver was then fitted with larger pipes and arrangements, so as to receive a uniform distribution of the iron in the cylinder, and to prevent it being washed away by the too rapid current. It was sent to Antwerp in February of this year, and has been steadily at work ever since with the best results. The head available is only 5 feet, but large pipes allow 166 gallons per minute to pass through, which gives a contact of 3½ minutes. The charge of iron is about 500 lbs.; the quantity taken up, including impurities, and the very fine iron washed away during a run of 33 days, was 0·176 grain per gallon, the consumption being 20 lbs. for the filtration of 1,000,000 gallons. The area of the apparatus for dealing with 2,000,000 per day is 29 feet by 24 feet. The revolver turns at the rate of about ⅓ revolution per minute, and requires scarcely appreciable power.

This process of exposure to iron decomposes all organic matter, kills all living organisms, and removes all colour caused by peat or clay. The water, after proper subsequent exposure to the air and filtration through sand, nearly resembles the colour of distilled water, and the free ammonia was reduced from 0·032 grain per gallon to 0·001, and the albuminoid ammonia from 0·013 to 0·0045.

Mr. Dickinson said that at this late period of the meeting there was not time to discuss the subject fully, but that as the bursting of water into the Moston Colliery was touched upon in the paper and had a local interest, he might mention that in his own mind there was no doubt the water came from the overlying sand and not from the strata as left by the paper an open question. That when about 40 or 50 years ago the late Mr. Stanley succeeded in sinking his first shaft through the sand and soils at Moston, it was considered a great achievement, so many previous attempts having failed. There is a covering of sand of 60 yards or more in thickness, much of which is broken up and mixed with some clay, but at one place a fault in the coal workings may be seen rising through bedded sand (apparently Permian) to the surface of the ground. The fact of this sand containing a large quantity of water had been known for a long time, and he had cautioned Mr. Stanley against working far on the rise lest the water might break into the workings, and this caution he communicated to the present owners on their taking the colliery. It seems that it is about 120 yards below the surface where the water has broken in through the roof of the mine.

The further discussion on Mr. De Rance's paper was postponed to a future meeting.

ON AN AUTOMATIC SAFETY LAMP.

By Joseph S. Martin, F.G.S.

I recently visited Mr. C. E. Rhodes, General Manager of Messrs. John Brown and Co.'s Rotherham Collieries, in order to see the lamp testing arrangement which he has had erected at Aldwarke Main Colliery, where the Committee of the Midland Institute of Mining, Civil, and Mechanical Engineers made the experiments upon which they based their important reports published in that Institute's Transactions, Parts 70 and 71; through his kindness I saw a number of lamps tried, and was much struck with one which burned in a current of 51ft. per second with perfect steadiness, and in which upon the current being made explosive all flame was quickly extinguished.

The principle of the arrangement was communicated by Mr. Evans, a Welshman, who is not practically acquainted with mining, to Mr. Rhodes; to the latter is due the credit of adapting it to a useful and practical form.

Mr. Rhodes has, at my request, kindly forwarded me a lamp to show at this meeting, and I only regret that you are not able to see it in the very complete testing arrangement at Aldwarke Main Colliery.

It is an ordinary lamp of the Clanny type, provided with a cap or extinguisher made of tin, which fits loosely outside the gauze. When in position for extinguishing the flame this cap stands on the flange, which encircles the bottom of the gauze, and the opening in the top is at the same time closed by a cone fixed for the purpose.

When the lamp is in use this cap is held up about half

an inch by a wire rod which passes down through the flange to the interior of the lamp, where it is hooked to a thread, or other suitable fibre, placed in the gauze above the flame, and from which it is protected.

The air necessary to maintain the flame thus passes under the cap to the interior of the lamp, and the products of combustion escape through the opening at the top.

When the lamp gets into an explosive mixture the burning gases inside the gauze consume the thread, and the rod thus disengaged drops down and brings the extinguisher into immediate action.

The lamp is further provided with a second shield outside the extinguisher, but it is merely one of the "Smethurst" type for the purpose of breaking the velocity of the currents in which the lamp may be placed, and has nothing to do with the speciality which I wished to bring before you.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XVIII. SESSION 1884-85.

At the ORDINARY MEETING of the Members of the Society, held on Friday, January 9th, 1885, in the Mining School Buildings, Wigan;

W. S. BARRATT, Esq., Vice-President,
in the Chair.

NEW MEMBER.

The following gentleman was elected an ordinary member of the Society:—

CHARLES WILLIAM BICKERTON, Hazel Grove, near Stockport.

NOTES ON AN AUTOMATIC SAFETY LAMP, AND ON VARIOUS METHODS OF LOCKING SAFETY LAMPS.

BY J. S. BURROWS, M.E.

Mr. Martin, our Honorary Secretary, having forwarded to me for trial a lamp lent to him by Mr. C. E. Rhodes (and described at the last meeting), wished the results of such trial laid before the members of the Manchester Geological Society. This I do with great pleasure, only regretting that I have not more information to give about the lamp.

As to its construction, an inspection of the lamp now before you will be more satisfactory than any written description. Briefly it is an ordinary Clanny lamp, fitted with an "extinguisher," capable of closing when down the inlet and outlet air holes of the lamp, this again being enclosed by an outer shield similar to that of the Marsaut lamp. When in use, the "extinguisher" is propped up by a piece of iron passing up through a hollow standard. The bottom of this piece of iron is formed into a kind of hook which rests on a piece of thread. The theory of this arrangement is that whenever the lamp is filled with gas the thread shall burn, releasing the upright piece of iron or prop, and allowing the "extinguisher" to drop and cut off all communication with the outside air, which of course puts out the light.

It is needless to point out the advantages of being able to use a Clanny lamp when working, as it gives a good light, is much less liable to go out if tilted on one side than the Mueseler; and if the "extinguisher" really does its duty in the presence of a dangerous quantity of gas, equally as safe, if not safer, than the best lamp known.

Unfortunately, I am unable to say definitely from experience that the "extinguisher" does so come into play when the lamp is placed in a current of gas and air, as the apparatus we had erected for the purpose of experimenting with lamps some years ago has been demolished, and I have only been able to watch the behaviour of the lamp in out-of-the-way workings where gas could be found, and where there was no current.

The lamp was first tried with an ordinary gas jet on the surface, but the thread would not burn unless the lamp was so placed that the gas entered on the side where the thread was, but by so placing it the "extinguisher" was brought into play and the light put out. On trying the lamp in

gas underground the lamp went out just as any other lamp would do, but the thread was in no case burnt. In all the trials underground the gas was little if any diluted with air, and it is my opinion that if the gas were diluted with air sufficiently to burn briskly inside the lamp, the thread would burn and allow the "extinguisher" to come into action.

With a view of testing whether the thread would break in ordinary use, when not required, the lamp was given to colliers and drawers instead of their own lamp. They were very pleased with the lamp after their own Mueselers, and the thread did not give way in a single instance.

If, however, the lamp should prove to be so sensitive in a current of air and gas, it is an open question whether it is an unmixed benefit to be left in the dark when one's lamp meets with perhaps only a small quantity of gas, as, say, when a longwall face is "weighting," or when "prop-drawing."

Much attention has of late years been given to the improvement of safety lamps, but I have not noticed much said about the proper method of securing or locking the lamps when lighted, so as to prevent the flame being exposed either by accident or design. As this is a very important part of the question, I venture to take this opportunity of bringing the subject forward.

The devices for preventing the opening of safety lamps when at work are:—

1st. The screw lock, when a short screw is tightened

(*a*) against the threads on the lamp bottom; or

(*b*) against the lamp bottom below the threads; or

(*c*) from underneath through the lamp bottom, and against the bottom ring of the lamp top.

2nd. A hasp attached to the lamp top passes over a pro-

jection on the bottom, and is secured by a common brass padlock and key.

3rd. The magnetic lock, as in the Wolff lamp, when the lamp bottom has to be placed over a powerful magnet before the lock bolt can be released to allow of the lamp being unscrewed.

4th. The Protector Lamp and Lighting Co.'s Patent, where on attempting to unscrew the lamp bottom the wick tube and flame have to pass through a collar held in its place by a simple arrangement with a spring, and which thus extinguishes the light. There is a second locking arrangement with a lead rivet as well.

5th. Lead rivets, either

(a) with an ordinary hasp; or

(b) where two projections on the lamp top and bottom are brought opposite to one another, and the rivet passed vertically through them. In either case, the rivets are pressed between two dies which mark each end of the rivet with some device or initials.

With regard to screw locks, they give no security whatever. Any screw has always a tendency to slacken when there is any jolting or vibration. Again, if in locking, the end of the screw, instead of resting in its usual hole, is just on the edge, the first knock the lamp receives in working probably causes the screw to slip off the edge into its proper place, when it is slack at once. Moreover, the head of the screw lock on which the key fits wears away rapidly, and it soon becomes difficult to screw it up properly. Lastly, any one can open the lamp with a key, a nail, and even if the lock projects with his teeth, and screw it up again in the same way, the screw giving no indication that it has been tampered with.

With regard to padlocks, they are of the commonest kind,

and duplicate keys are easily obtainable. They also tell no tales when they have been tampered with.

The writer has never seen the magnetic lock in actual use, but thinks it is a satisfactory means of securing the lamp.

The Protector Lamp Co.'s arrangement is certain to extinguish the light when the bottom is unscrewed if the spring is pushed home and in its place, but a match would re-light the lamp; and were it not for the second lock with the lead rivet, would not show that it had been so treated. The lessening of the flame is effected by partially unscrewing the bottom, and in carrying the lamp, the bottom has a trick of coming unscrewed until stopped by the second lock.

The system of securing by means of lead rivets is not open to any of these objections. The rivets are stamped in the morning before the lamps are given out, and remain just as they were put in unless the head is cut off. The person who defaces the rivet cannot replace it unless he possesses a new rivet, and a facsimile of the particular die in use; and the knowledge that when the lamp is handed in to the lamp room it will tell its own tale is sufficient to deter anyone from meddling with it. At the lamp stations for re-lighting lamps underground, this locking, or rather stamping arrangement, is kept in a lock-up box, the key of which is in the possession of the jigger or other person appointed, and who is the only person allowed to re-light the lamp. Of the two plans, I prefer the one where the rivet is placed vertically through two projections on the top and bottom, as there is sufficient play in the hasp to allow of the bottom dropping down in case the thread on the lamp bottom is much worn; such a case has come under the writer's notice.

This question of securing lamps is very important on two grounds:—

1st. It is no use having a perfect lamp in use if the

light can be exposed by anyone without much difficulty or fear of detection.

2. Managers are exceedingly strict in enforcing the rules as to lamps, which is as it should be; but, on the other hand, we ought to be as particular in seeing that the means for securing the lamps are such as to leave no manner of doubt that they might, as I have tried to show with screw locks, come loose without any interference on the part of the workman. Contracts to be binding must be mutual, and it is the duty of all concerned, whilst enforcing the rules to the utmost, to take care that it is not possible for an innocent workman to be sent to prison through having an antiquated and unreliable method of locking lamps.

The writer thinks that the question of lamps and locking will never be satisfactory so long as men are made to find and clean their own lamps. I believe that this bad system is dying out, but there are still many places where it is in force. A man who is required to provide a Davy lamp at one colliery must perhaps find a Mueseler if he moves to the next colliery, and possibly keep two or three other sorts if he wishes to extend his movements, and it is only natural that he will buy the cheapest and therefore the worst he can; also, he will put off renewing the gauzes, &c., as long as they will pass the fireman's cursory examination when he goes to his work. Moreover, it is not easy to make a change of lamps when the men have to find the money for a new lamp, in the choice of which they have had no voice, and which may possibly be of no use if they leave or are dismissed a fortnight afterwards.

Mr. Tonge said he fully agreed with the author of the paper that it is desirable that the lamps should be found by the proprietors. He was quite of Mr. Burrows's opinion that where colliers had to find their own it led to very defective lamps being used.

Mr. W. PICKARD: Have you used these lamps below in the hands of workmen?

Mr. BURROWS: Yes.

Mr. PICKARD: What is your experience?

Mr. BURROWS: They like the lamp, and they would have it every day if they could, because it does not go out.

Mr. WINSTANLEY said the lamp was a very ingenious arrangement, but it was a question as to how far a collier or other workman down a pit would be justified in remaining in an explosive atmosphere a sufficient length of time for the thread to be burned through. It, however, is a question whether he should retire from his working place or wait until he was left in total darkness. Speaking for himself, he should not like to remain or to work in a colliery where there was a sufficient quantity of gas to keep flickering and burning in the lamp until it burnt the thread.

Mr. BURROWS said the object of this arrangement was to prevent the lamps being used where the gas burned in the gauze. A collier working at the face has not always got the lamp under his observation; it probably would be some feet behind him. The first intimation he would get if gas accumulated suddenly or if a current he was travelling in became explosive, was the extinguishing of the lamp. If he were working in a dusty place, or if dust was raised by his drawer, he might think nothing about his lamp flickering, and would think it was caused by the dust, and continue working until it became red hot without knowing it, but with this lamp there could be no mistake, because it would go out at once.

Mr. MARTIN said that at the Aldwarke Main Colliery he had seen the lamp tried in a current of 51 feet per second; it remained burning for a very few seconds, and the extinguisher then came into effective operation. The extinguishing arrangement had, in his opinion, nothing

whatever to do with the question of a collier remaining in a place where there was gas, as the law required their immediate withdrawal until it was set right. This arrangement is intended to prevent their remaining with a light when gas exists in the air to a certain extent. For some time past the subject of the secure locking of lamps had come prominently under his notice, inasmuch as when visiting various collieries he had found a very considerable number of insecurely-locked lamps in the hands of colliers, who were, according to the rules, responsible for their being so. He had proved in many cases that the lamps when placed in the colliers' hands had been duly locked, but from some cause or other they had worked loose. The question therefore arose in his mind, how far it was right for an insecure system of locking lamps to be allowed. The subject is an important one for employers, but still more so for the men themselves, as the penalties to which they are liable for having an insecurely locked lamp in their possession, even unwittingly, are very severe. No doubt the locking of the lamp had nothing whatever to do with the actual safety of the lamp. The object of locking the lamp is to render it as impracticable as possible for a man to open it. Mr. Burrows stated in his paper that it is not satisfactory that the men should find their own lamps. In this country in some places such is the custom, and so far as the law was concerned there was nothing against it. In Germany, it was by law obligatory that lamps should be provided, cleaned, filled, lighted, and handed to the collier ready for use, and a charge is made to the men at a minimum rate by the day or week worked. He at one time had nearly got into trouble with the authorities, being unaware of this requirement, by letting the colliers clean the lamps themselves.

Mr. W. Pickard asked what effect the shield (Smethurst

or Marsaut) was found to have upon the temperature, and whether the men approve of them?

Mr. MARTIN said that he was informed they do, and that they like the lamp very much.

Mr. PICKARD: Do they approve of the heat retained under the cover?

Mr. MARTIN said he had not heard any objection on that point either from the men using them or from those in charge of the mines.

Mr. PICKARD asked if in a confined place the high temperature arising from this lamp must not have a serious effect upon the sense of seeing?

Mr. MARTIN said he had never heard anything of the matter. He had heard no complaint, and had no cause from his experience to think there had been any inconvenience felt from such slight extra accumulation of heat.

Mr. BURROWS said that he has about 300 of them in use, and the men never raise the question at all.

Mr. PICKARD asked if he was to understand that Mr. Burrows's experience was that there is no higher temperature with these shields on than without them?

Mr. BURROWS: Certainly.

Mr. PICKARD said he had a strong objection to the shield himself. He would follow Mr. Martin or Mr. Burrows, whose experience was wider than his own, from observations and statements of the workmen, but he naturally thought if he should put another tin shield upon his lamp he should have a greater temperature.

Mr. MARTIN said his own experience in carrying it was not so, as he had not found the shield get exceptionally hot.

Mr. PICKARD agreed that in carrying a lamp in contact with the atmosphere it is so, but where it is a place in which there is just sufficient air to make it burn, the heat must be greater than the ordinary Davy.

Mr. MARTIN : I have never heard any objection to it, and there are a large number of them in use.

Mr. HALL (Inspector of Mines) said that so far as this part of the world was concerned, they practised both systems with regard to lamps. Some owners thought it best to find lamps, and some thought it best that the men should find the lamps, because they thought the men would look after them better than they themselves could. Personally, he thought there could be no doubt the better plan was for the owners to find the lamps.

Mr. W. PICKARD said he quite endorsed the remarks of Mr. Burrows in that matter. He should like to see the day when every proprietor would feel it his duty to provide lamps. It was a question of safety, economy, and convenience, and he respectfully submitted that some of the workmen had not the proper appliances for keeping their lamps in order. They had an assistant in the shape of a little girl, who knew no more about a lamp than a horse-collar as to cause and effect. She was sent out to get oil, and one thing and another, and it was a painful fact that men thus got inferior oil, and took it into the mine, and very serious consequences might sometimes be the result. He would like to see the day when all lamps must be given out to the men clean and in order at the respective collieries. He was sure the nation and the district that adopted that system acted in the way to protect life and give comfort.

Mr. BUDENBERG exhibited a Wolff lamp, and explained that the lamp could be lighted when it went out by simply pressing a trigger underneath the lamp. He further explained the system of locking and unlocking the lamp, and demonstrated that it could only be unlocked by means of a powerful magnet.

Mr. MARTIN said Dr. Foster showed the same lamp at a former meeting here in Wigan.

Mr. BRYHAM expressed a doubt whether it would be safe in a mine where there was gas to cause an explosion such as resulted from the detonator by which the ignition was accomplished.

Mr. JOHNSON, M.G., said he had an objection to the use of the spirit lamp. The men at his collieries refused to use it, because at the very slightest jerk it went out. At one colliery he knew they had to provide a duplicate set of lamps. That if it was decided to provide lamps, the great question was what lamps should be used.

Mr. BURROWS said he had seen many men returning home with their Davy lamps, and he had got them to take them to pieces and show them to him. He would at his collieries condemn many of those lamps. As long, however, as the lamps would pass, the men would not provide new ones. It was only a small matter to provide lamps for even a large colliery. It was perhaps a matter of three or four hundred pounds, which, if any accident occurred through a defective lamp, would go a very short way towards setting matters right, irrespective of the loss of life.

Mr. JOHNSON said the expenditure of hundreds of pounds upon lamps could hardly be called a small matter, at any rate until one was satisfied which was the best lamp.

The CHAIRMAN (Mr. Barrett) said that as an owner he entirely agreed with the remarks of Mr. Pickard. They were not a bit too strong. He thought it was a matter of the greatest necessity that every colliery should find their own lamps. If a colliery found their own lamps, there would be uniformity; but if the men found the lamps, they simply went and bought the lowest class of lamp that would pass muster. There was no doubt a great element of danger in the men finding their own lamps, because they sometimes went down with a lamp

in a very defective state. He thought the extra cost would be compensated for by a greater sense of security, and the knowledge that every man when he went down had a perfect lamp with good oil and wick, and that the lamp was thoroughly cleaned before the men had them. Of course it stood to reason that every colliery owner would get the lamp he thought best, and he would not be expected every time a new lamp came out to adopt it. Many points had, he thought, been cleared up in the discussion which were not before plain to his mind.

DESCRIPTION OF STEEL TUBE GAUGE FOR PRESSURES

OF 120 LBS. TO 10 TONS ON THE SQUARE INCH.

By Arnold Budenberg.

None of the ordinary steam pressure and vacuum gauges can be applied for indicating constantly such high pressures as 300lb. per square inch, and still less so pressures very much higher which are needed for high pressure tubing, hydraulic presses, &c. Messrs. Schäffer and Budenberg have succeeded in constructing gauges which have overcome these difficulties, and on the table will be seen the working parts of such instruments; some of the springs being finished and others partly in the way of construction. In manufacturing these springs, steel rods of the highest quality attainable are cut to the proper length of the springs required; they are bored out, and turned off outside, except the ends, to which a suitable thread is screwed. (Fig. 1.) The two cases placed on the table contain each one of these

Fig. 2.

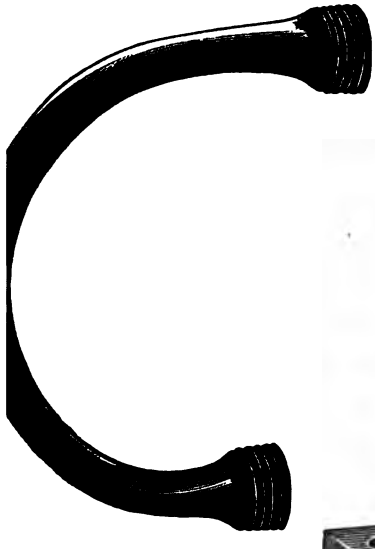
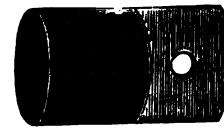


Fig. 4.



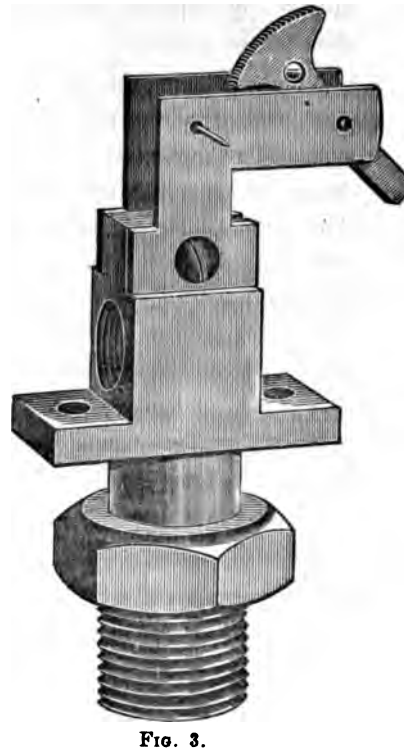


Fig. 5.

Fig. 3.

ght rods finished up to this state. After having been nitted to the required heat, they are bent, in which ation they are at the same time flattened and con-

for a 4in. gauge to indicate a pressure of 500lbs. on the square inch, and se made for pressures of from 120lbs. to 10 tons on the square inch. Those ic purposes are provided with self-registering pointers to indicate the essure attained.

veniently shaped. (Fig. 2.) They undergo a process of tempering, and hereafter the one end is screwed into the stem or principal part of the gauge (Fig. 3), through which the pressure is carried on from the generator, and upon other end is screwed a solid piece of metal (Fig. 4), to which the rod is fixed transmitting the movements of the steel spring by suitable gearing (Fig. 5) to the pointer and dial of the gauge.

The larger case on the table contains the parts and spring as described before, suitable for a steel tube gauge with 7in. dial, indicating 120lbs. pressure per square inch, the lowest range of pressure for which these instruments are made. The smaller case contains the parts and spring of a steel tube 4in. gauge suitable for 500lbs. per square inch. The springs for gauges to indicate the very highest pressures are prepared in a similar manner, the lower pressures requiring the larger tubes.

This solid steel tube spring is exceedingly durable, retaining perfect elasticity, and has the great advantage that all soldering is avoided, which is requisite in the Bourdon and other constructions in which the spring consists of a tube.

These gauges were originally only intended for hydraulic purposes, but the principle has been so far modified as to allow of its being applied to gauges for all ordinary steam pressures, and they register the lower pressures with as great accuracy as the higher ones, and are now very extensively used, and their superiority recognised by leading engineers and steam users.

The solid steel tube gauge, arranged for steam pressure, is represented in Fig. 6 with open dial, allowing to a certain extent the arrangements of the described parts to be seen.

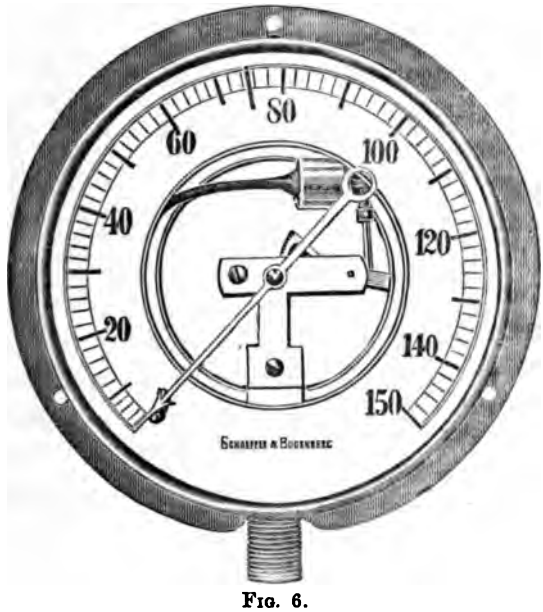


Fig. 6.

These high pressure gauges, in addition to their application to hydraulic presses, are exceedingly useful in ascertaining the breaking strain of iron and steel bars, chain cables, water pressure in accumulators, air compressors, as also in connection with the manufacture of torpedoes, for which purposes they are used at the Arsenal at Woolwich, Sir William Armstrong and Co.'s and Sir Joseph Whitworth and Co.'s, and others.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XVIII. SESSION 1884-5.

EXTRA MEETING of the Members of the Society, held on Tuesday, the 13th day of January, 1885, in the Owens College, Oxford Street, Manchester;

MARK STIRRUP, Esq., F.G.S., Hon. Secretary, in the Chair.

The meeting was specially convened to hear an address by Professor Boyd Dawkins, M.A., F.R.S., on "The Carboniferous Flora." The address was illustrated by specimens from the Geological Museum, which was open during the evening for the inspection of the members.

The CHAIRMAN said the committee were very glad to meet the members of the Society in that building, which enabled them to be somewhat nearer to that collection of fossils which a number of years ago was the property of the Manchester Geological Society. That collection was, under an arrangement with the authorities of the Owens College, and by a deed of gift, transferred to the College; but unfortunately, owing to the want of space, it had hitherto been so placed as not to be readily accessible. It had always been the feeling of Professor Dawkins and many of the members of the Society that those collections should be made more serviceable; and it was hoped by a series of evening meetings to interest the members of the Geological Society

in them by taking some portion of the collection as the subject matter for discussion. Professor Boyd Dawkins had very kindly consented to give them the first lecture. He might say that the Principal of the College (Dr. Greenwood) and the Treasurer (Mr. Neild) had very readily and very courteously permitted the Society to meet within that building; and they had the further advantage of being able to inspect the museum, which would remain open during the evening. He hoped it would not be the last of such meetings, for he felt there were many gentlemen who, unable to attend the afternoon meetings in George Street, would gladly spend an evening occasionally at Owens College. It might be well to state that, under the arrangement with the authorities of the College, the geological collections were to be open to the public free on Tuesdays, Thursdays, and Saturdays, from ten a.m. to four p.m., and on Saturday evenings from 6-30 to nine. They were open also to students on Wednesdays and Fridays from 6-30 to nine p.m. It was further agreed that "the persons who were lately governors of the Manchester Natural History Society, and the members of the Manchester Geological Society for the time being, have free access to the museum for themselves and friends on each week day (Fridays excepted)." There was rising, adjacent to the College, a new building which would become the home of that museum, and their hope was that they might be able, before a very long time had elapsed, to hold a meeting within its walls. In the meantime they could only make the best use of the facilities they had. In that building were many geological treasures, some of which were of the highest value, which were practically unknown to many of the inhabitants of Manchester. They might, therefore, look forward with interest to the time when those collections—which were increasing almost daily by purchase and by

gift—would be arranged in their new quarters, and when the public of the city and district would, it was hoped, be found to take a pride in the Manchester Museum. He had now much pleasure in asking Professor Dawkins to proceed with his lecture.

Professor DAWKINS said: "This is a fitting opportunity for me to say a few words regarding the relation of this museum to the Geological Society. In the first place, with regard to the geological part of the museum, I would say that the collection of carboniferous fossils which we have here, is second to none that I know of anywhere in the world. It is due mainly to the labours of the Geological Society—to old and distinguished members who have now passed away. There is therefore an organic connection between the Geological Society and those collections, of which we see around us but a fragmentary portion, and which we hope, in the course of eighteen months or two years, to see housed in very different quarters. This is an occasion on which I may point out to you that a Geological Society, in the very nature of things, must have a collection. If the Society is to flourish it is necessary that there should be a collection to which the members can refer—as necessary as it is for the student, say of literature or history or languages, to have a library to which he can turn for needful information. I hope from this time forward the connection between the Manchester Geological Society and these collections will be much closer than it has ever been, even in the days when the Society was under the same roof as the collections themselves. But I am here this evening not to make a speech about general principles, but to put before you, as distinctly as I may, a few general considerations relating to the carboniferous forests with which most of us are intimately connected, and to which in a remote degree the very existence of this great city is due. Where would Man-

chester be at the present time—where would the manufacturing industries of this country be—if it had not been for those forests which I have to put before you in outline this evening? I say in outline, because I know full well that if I were to expend upon the subject hours upon hours of most elaborate discourse I should still be unable to exhaust it. I will, therefore, begin by placing before you exactly what a seam of coal is—hoping that those of you who are acquainted with coal will pardon the simplicity of my approach.

There are in coal two distinct elements: First, there is the bright glossy element which will not soil your fingers; and secondly, there is the powdery black element which, if you handle a lump of coal, will make your fingers as black as you like. These two elements are absolutely distinct, one from the other. The bright portion which will not soil your fingers is distinctly of resinous origin—it is really a fossil resin—and the black element is, as you all know, vegetable tissue converted into charcoal.

Having shown by drawings how the resinous element is distributed through the coal—how it originally had the form of rounded bodies, which now present the appearance of having been crushed flat—Professor DAWKINS said: "The coal which contains the largest number of these is what we know under the name of blazing coal. "Bituminous" coals also possess this element in considerable quantity; and supposing you examine under a microscope a piece of cannel coal—Wigan cannel say—what you will find is this: You will find that it is full of minute fragments, which have all been broken and shattered, and therefore, being small, are packed closely together. Thus you get more resinous matter in the cannel coal than in ordinary blazing coal. If you examine a series of samples of steam coal, which, as you know, is not nearly so blazing as the ordinary "bituminous"

coal, you will find these small round bodies in small numbers; whilst, if you examine the anthracites, you will find there is none at all. There is a gradual shading off of these round resinous bodies in the coal, from the blazing coals through the steam coals into the anthracites, until we lose trace altogether of them. The next point to be considered is—What are these round bodies? They are, really, the minute spores of plants closely allied to the club-moss, which is so exceedingly common on the northern slopes of most of our English hills. The blazing property of coal depends upon the amount of these resinous spores, and, in order to prove to you that they are highly inflammable, I will try an experiment with the contingent possibility of burning my fingers, which of course will add point to what I am saying—(Professor Dawkins lighted some lycopodium spores to show their inflammable nature). You will quite understand from that experiment how the blazing property of coal may be related to the amount of these resinous bodies which it contains.

Now as to the plants to which these spores belonged. In the first place, I invite your attention to a sketch which looks very like a section through a fir cone. That cone belonged to a lepidodendron, of which you will see upon the table several illustrations. I have here one of the cones in question attached to the plant on which it grew. If you compare that section of a lepidodendron cone with a section of the cone of a club moss, you will see at once that really there is no practical difference between them. You see, then, that in these spores in the coal we have evidence of the existence of ancient kinds of club mosses, which are familiar to geologists under the name of lepidodendra, on account of the scale-like markings on the outer surface of the stems. In the museum presently you will have an opportunity of seeing numerous examples of the cones; and if you

examine the branches you will find that they dichotomize exactly as in the ordinary club moss. The leaves of the lepidodendron all have the same scaly character, and are very much like the leaves of the club moss. The general idea that you must form of the tree is one I have attempted to represent in a diagram before you. It was tall and upright, and of the size of a forest tree.

Now for the roots. I have no doubt that you are all familiar with the stigmaria—those pitted and dotted root structures which are invariably present in coal pits. The lepidodendron undoubtedly had a root of that kind; it was a root which, at the base of the trunk, divided into four parts. These again dichotomize into eight, and so on, as Mr. Wild, who is present this evening, has shown me so well in the colliery under his charge. In that colliery I have seen what I have never seen elsewhere, and it is a most impressive sight to have witnessed. I have lain flat on my back in the workings of the colliery, aud, looking up at the lower parts of one of those great roots, I have seen the division into four first, then the division into eight, further away, and afterwards into sixteen, without coming to the end of the roots.

But now what shall I say of the rootlets? The stigmaria had rootlets which were articulated to it, and which are universally found in the under clay, or ancient soil, in which the carboniferous vegetation grew. The rootlets look like long compressed blades of grass in the fossil state. You will see, in the collection in the other room, numerous illustrations of the rootlets in question; and if we had had the opportunity—which unfortunately we have not in this room and with this light—I could have shown you illustrative sections under the microscope.

What shall I say of another kind of tree—a tree whose stem exhibits flutings like those on a pair of corduroy

trousers—the sigillaria? This sigillaria, as Professor Williamson has shown us, is nothing but a lepidodendroid tree. It is not a true lepidodendron, but it comes so close to it that it may be said to be a first cousin. Then with regard to the foliage and roots: there seems pretty good reason to believe that the foliage is indistinguishable from that of the lepidodendron; so that, really, the figure of the lepidodendron will very well stand for the figure of the sigillaria.

But now I would like to say a word regarding an aberrant form of these lepidodendroid plants. You will see in one of the cases examples of a fossil bearing the name of the ulodendron. This was a tree which had lozenge-shaped markings on the outside of the stem, but besides that it was stamped more or less with a sort of rounded scar, which scars were really the bases of cones—cones of the same general sort as those you have already seen, which stuck close upon the sides of the branches, and left the impression of the bases when removed.

Besides those which I have mentioned to you there is another tree, represented very generally as in the specimen before you, by a cylinder, made up of a series of transverse joints, each of the joints being traversed by longitudinal markings. That structure would give you the impression at first sight that it was a fossil reed, hence the name—calamite. But in fact it is nothing of the sort. It is merely the cast of the interior of a great stem belonging to the forest trees, like the rest. It is to be looked upon as a hollow pith cavity, which has been filled with sand or mud, or whatever the infilling agent happens to be, and those little flutings which you see upon it are to be looked upon as the markings of the small ends of the little wedges forming a woody zone all round. Then outside that came the enormously thick bark. There is every reason to suppose that the

calamite was a vegetable which had not on the outside of its stem any trace of flutings. In all probability it was a smooth stemmed plant, of enormous size, if we may judge from the diameter of some of these casts. In speaking of casts, I should like to mention to you that we get these forms of vegetation preserved in all sorts of curious ways. Sometimes there is nothing left of the vegetable but a cast of the hollow which was occupied by the pith; in other cases we have the wooden cylinder preserved; in other cases, again, we have the bark preserved; so that really you may have half a dozen different structures and different representations of one and the same type of vegetation. It is due to my friend, Professor Williamson, that we are able to put together all these diverse observations, and knock on the head a good many hard names, and arrive at some definite opinion regarding the carboniferous forests. The general idea which you must form of the calamitean type is such as you see represented in the specimens before you—a long vertical stem giving out numerous branches at certain parts of it, and more particularly the upper part, and provided also in certain parts of it with cones, which contained spores that were inflammable, like the spores of the lycopodium. The calamite was a gigantic kind of equisetum or horse-tail. Most of us are familiar with the equisetum, and the general idea that we are justified in following, at all events in outline, is that the calamite was a kind of equisetum, differing, however, from that which exists at the present day, in the possession of a woody zone and in the absence of silica. But the mention of a woody zone reminds me of a very important fact connected with these two types, the lepidodendroid and calamitean. Neither the equisetum or mare's tail, nor the lycopodium or club moss, have any such woody zone; and it seems very probable that Professor Williamson is perfectly right in saying that

development of a woody structure in the fossil plants is related to the fact of their being forest trees. Of course they would require some stiffening in order to be able to lift their heads up in the primeval forests then covering the surface of the earth.

There is a source other than the spores from which the resinous matter in the coal may have been derived. On one of the tables you will see a number of trigonocarpa—small triangular fossils. If you compare these trigonocarpa with the fruits of the living Salisburia and the Araucaria alongside of them, you will see that they are of the same type. The Salisburia and Araucuria belong to the Conifers—to a type of trees in which large quantities of resin are stored up in the cells in the wood. The decomposition of the tissue of these trees would of course result in the accumulation of resin in proportion to the number of trees. I have no doubt whatever that a large quantity of the resin in the coal has been thus derived.

Another source of this resinous matter is to be found in the ferns. In the fructification of the ferns resin is secreted, and when I ask you to glance presently at a few typical ferns, which I have on one of the tables here, you will see that in the coal measures, in the abundance of ferns, we have an ample source for the supply of resin. Thus, you see, in any inquiry into the origin of the resinous matter in coal we are really brought face to face with the salient points in the carboniferous forests. The idea you must form of those forests as a whole, is that they were dark and sombre, composed to a large extent of conifers—pines, and the like, with an undergrowth of ferns, and among them tree ferns, as well as of singular lepidodendroid trees, the sigillaria and lepidodendron, the ulodendron and some others, and of the stiff-branched calamite.

What animals lived in these forests? We have just a

trace here and there of the carboniferous fauna. The highest form of which we have any knowledge is represented by the cast on the table before you, of a skull of labyrinthodon, a large crocodile-like amphibian. But we have evidence that those forests existed under tropical conditions in the existence of gigantic spiders, you will see upon the table an illustration of this fact in the cast of a gigantic spider allied to one of those found at the present day in the forests of Brazil. The original was found at Coalbrookdale. On the whole, in those carboniferous forests, we have but scanty trace of life, other than vegetable, a few beetles, a few weevils and other insignificant form of insects, such as centipedes and some others.

What were the conditions of the growth of these forests? All of you—at least those of you who are acquainted with coal mining are perfectly aware that, as a rule, beds of coal occur on an "under-clay"; that is to say, on a deposit which if not of clay is always traversed by rootlets. These rootlets, mainly, are lepidodendroid; consequently it is clear that these forests grew on an ancient land surface, and that the rootlets belonged to the trees which have largely built up our seams of coal. In many cases you can trace the rootlets up to the lepidodendroid trunks. The coal therefore was formed on the land by the growth of vegetation, after the fashion of peat. It is a fossil peat bog. So much for that point; now I want to mention another fact which is to my mind of singular interest. If you examine the surface upon which these coal seams rest, as a rule, you will find that they are parallel to one another. Why is this? It has this important meaning—that in ancient times the ground upon which the successive forests grew was horizontal; in other words, was alluvium. From time to time these alluvia were depressed. While I am speaking about that, let me just explain a fact which otherwise to my mind is inexplicable. The coal

measures of Lancashire amount, in thickness, to over 7,000 feet; and if you examine the component elements of the vegetation of the lower coal measures and compare them with the upper, there is not as far as I know any difference. There are the same lepidodendra, the same conifers, &c., right away through. Why is that? The alluvium in which the trees grew was near the water line—in some cases near the sea; in other cases on the margin of fresh water, as in the middle coal measures in this county. The forest growing down to the water line will have extended up into the uplands, and an accumulation of vegetable matter formed on the ground. Then a depression took place, which is marked by the sandstones and shales covering the layers of coal. The ancient forest growing on the alluvium was submerged; then sand and mud would accumulate—sand banks and mud banks would appear—now forming the roof on the coal. When silting had taken place up to the water line, the forest would spread from the uplands over the new horizontal alluvium; and ultimately there would be a new forest growing immediately over the old one. This process repeated over and over again will explain the reason why, in a given sinking, beds of coal are practically parallel to one another. This explanation (which is a most simple one) will account for another fact—that a seam of coal sometimes splits into two or more thinner seams, as for instance at the main coal of Staffordshire—the ten yards coal.

In conclusion, I would like to say a few words regarding the ancient geography of this country during the time when these carboniferous fossils flourished. In the first place, I would like to remind you that of the vegetation growing in the higher part of the uplands we have no trace whatever. All the coal of which we have any knowledge in any part of the world grew on areas that were perfectly horizontal and of the nature of alluvium—sand banks, mud banks, and

the like. It would then, seem pretty clear from the distribution of the coal measures in this country that the alluvium upon which these sombre forests grew—forest succeeding forest for an untold series of years—extended from the area of the Highlands, through the Lowlands of Scotland. The mountain area of Cumberland and Westmoreland—the high area—was an upland overlooking this great tract of alluvium, which reached over Northumberland, Durham, Yorkshire, Lancashire, and into Cheshire, and extending on the one hand as far as Anglesey, and on the other down the line of the Severn over South Wales, and sweeping, too, from the area of the Somerset border of Devon far to the south, across into Brittany, and far to the east over south-eastern England into the valley of the Rhine. The uplands are represented in the main by the Highlands of Scotland, the highlands of Cumberland and Westmoreland, and the highlands of Wales, and, I would add also, the highlands of Devonshire and Cornwall, especially of Cornwall, although they are now scarcely to be counted highlands. In Ireland, too, in these times there was as abundant a store of coal as there is at the present day in this country. There were, however, certain isolated uplands in Ireland, such as those we find in the far west in the area which is occupied by the metamorphic or archaian rocks. The present coal fields are merely isolated fragments of this vast horizontal plain.

This plain at the close of the carboniferous times was thrown into a series of folds; the exposed portions were washed away by the force of the waves upon the sea shore, by the erosive agency of snow, rain, and ice, until the different coal-fields were separated, and covered in part by newer rocks.

In conclusion, I will only add that I am here this evening not to give a set lecture, but to direct your attention to the riches of our museum, and to lay before you what they teach.

When they are properly housed in their new quarters, I look forward to them being utilized for the advantage of the Society and of the public, and in the general interest of education in this district.

The CHAIRMAN called attention to the fact that as Professor Dawkins was concluding his address, Professor Williamson entered the room; and the meeting would be glad, he was sure, to hear a few words from him. He believed there was no greater living authority than Professor Williamson on the minute structure of the coal plants.

Professor WILLIAMSON said: I really feel myself in a most anomalous position, being asked to give you a speech without a text, and without the faintest idea of what has gone before; whether what my old friend and colleague has been saying to you is such as I could countersign, and which he possibly would say a great deal better than I could; or whether I shall have to take him in hand and pull him in pieces I cannot tell. I may take it for granted that you do not want me to go through the whole history of the Coal Measures; were I to do so, I should have to keep you here till this day week, and you would get only a sort of index to the subject even then. Looking at some specimens of fossil coal plants lying on the table before him, the Professor said, I find here some very curious things, which might easily be made the subjects of remarks, but it is difficult to determine what to select; one thing I may safely say; it is this; if you begin to study the plants of the coal measures, and make collections of them, you will be anxious to put names to those specimens. If so I wish you God-speed, but I beg you will not ask me to do it for you, because I cannot. I can put before you lists of wonderfully devised names, long enough to be German in their origin, some generic names and others specific ones

Well, I have been working at these things all my life long, more or less; but I know little about these wonderful names. I believe there is no delusion in the world greater than that of all these generic and specific names of the coal plants. If, for example, a man wants to get into a state of utter bewilderment, I will ask him to try to make out the different species of fossil ferns of the coal measures from the descriptions and figures of them published in America and Europe, in addition to what we have in England. Any confusion more complete than that occasioned by all this literature it is impossible to find. I dare say some of you know very well what I have thought and preached about this subject again and again; but it is all in vain. A man takes up a little fragment of a stone, and he finds a little fern, just the tip end of a fern leaf, upon it; he looks at it, and thinks there is a leaflet turned the wrong way, or there is some other trifle about it different from what is seen in something else; and therefore he must needs give it a grand name, with the little magical word *mihi* following. "That is my specific name; I discovered that species, and therefore," he says, "I was authorised to give it a name." I will venture to say there are scores and hundreds of names that have been concocted in that way, which are not worth the paper they are written on, because the describers have paid little or no attention whatever to the fact of the variability of these fragments of fern foliage when derived from different parts of the plant, and different fronds of the same plant. I have tried to teach this doctrine again and again. Sir Joseph Hooker tried to proclaim it years before I did, but in vain; the process goes on as mischievously as ever it did in days gone by. The ambition to be considered an authority in the species of these plants, and the ambition to give names to what are supposed to be new forms of these plants, overrides all the

warnings that have been uttered by those who know most about the subject. I am not going to affect a mock modesty. I believe that I have had more to do with these things, through a long life, than most living men, but I find myself the least able to do that which young men of five-and-twenty rush upon without hesitation. I would no more be the assistant curator of my colleague's museum and undertake to help him to name the plants that are in that museum, a superb collection; one of the finest collections, taking it as a whole, in the kingdom, than I would undertake to fly to the moon and take him on my back. The fact is, we have not yet reached a position which makes accurate nomenclature possible. I will give you an illustration of what I mean. There is a genus of plants very common in the coal measures, called *Asterophyllites* plants with star-like leaves. This plant has a stem which is thickened at each node; then the internode contracts, but the stem thickens again at the next node, and so on. Now, from each of these nodes there is given off a verticil of leaves. The leaves are arranged as you see them in that pretty, common plant the Woodruff, or any of the Bed-straws. Now this genus *Asterophyllites* was named from the circumstance that its leaves are arranged in a star-like form—hence the name implying star-shaped or star-arranged leaves. Well, in the young days of palæontological botany, that plant was considered to be a very definite one and easily understood, and one with a very appropriate name. But under that name of *Asterophyllites* we grouped together all sorts of things. I have no doubt whatever that a very large number of carboniferous plants had their leaves arranged in the manner described. I would merely ask you to go into our woods at the present day and take up a *Galium;* then take up the *Asperula* (woodruff), and others, of which many might easily be

enumerated—plants having the most varied affinities and the most diversified structures, their relationship being widely apart—from Cryptogams up to some of the highest flowering plants—and then try to classify these plants by the verticillate arrangement of the leaves. You cannot do it. New light has now been thrown on these plants. I have no doubt whatever that some of these so-called *Asterophyllites* are the leaves of a *Calamite;* others of them belong to genera that have an organisation, different from that of the *Calamites* as light from darkness. The fact is we have a very large number of plants, evidently of very diverse types, with the leaves arranged in this way. Only within the last three or four days another plant having this leaf arrangement is described in the *Comptes Rendus*, a plant belonging apparently to the pine family. Here we have a group of plants, to which the men, of whom I complain, have no difficulty whatever in attaching a common generic name whereas we have already found that these *Asterophyllites* belong at all events to several types of plants, and I have no doubt there are many other similarly miscellaneous types which we have yet to learn the history. Another great difficulty connected with this subject is one of a different kind. I would ask you to sow the spores of some of the *Aspleniums*—well known ferns—especially of some of those dimorphic ones where the barren and fertile leaves are so different. There are some fronds with spores on the backs of the leaves; others, on the other hand have no spores at all; they are sterile; you get leaves belonging to the same individual plant, but which are widely different from each other. Those spores, from whatsoever species derived, will, in 99 out of every 100 cases, come up with a single little leaflet which you will not distinguish in shape and size from the leaf of a maiden-hair. There is a curious tendency on the part of

these spores to germinate in the form of the maiden-hair. Darwin, with whom I corresponded on this subject, had an impression that these maiden-hairs, or *Adiantums* must have had something the ancient parentage of these ferns. However, be the case what it may, most of them begin to grow like the little maiden-hair fern. As these embryos of varied species grow, they develop each into its own peculiar form and gradually become as unlike each other as you can well conceive. Now, I want to know—are we to take all these things into consideration in classifying recent ferns, but ignore them in dealing with fossil ferns? If there is this variability in the lifetime of a single fern now, there was the same variability in the lifetime of ferns in past ages. Since the Devonian era the ferns have undergone smaller changes than most other groups of plants or animals. Time seems to have made very little difference in them, as far as their organisation and general aspect are concerned; they are substantially now what they were in the carboniferous age. Do not, however, misunderstand me. I do not say that you have in Palaeozoic rocks our modern type of Polypodium, and other recent genera; but you have tall, towering tree ferns and dwarf ferns, just as you have now; and in many other ways, the resemblance between what you had then and what you have now is very great. There is another fact also to be noticed. Most of the other Cryptogamic plants which we find in the Coal-measures have undergone development in thickness—that is, they have undergone exogenous growth; the Club mosses had it; the Equisetums had it; the Calamites had it, but the ferns had nothing of the kind. I mention these facts in order to point out that since the ferns have undergone so little change, we may fairly conclude that what we may call the polymorphism of the foliage, was in those ancient times, the same as at present. We can show that they sprang from spores as they

do now—differing only in points of detail—consequently we may infer, as I have said, that they had also this polymorphism. Then there is another great difficulty to be encountered in identifying fossil genera and species. No one presumes to identify living ferns by the shapes of their fronds and leaflets—they depend on the forms and positions of the sporangia. If recent botanists dealt with living ferns as fossil botanists do with fossil ones they would be in a state of bewilderment in half an hour. Well, we are creeping slowly towards knowledge that we did not possess before. Here and there we get fragments of fossil ferns in which these reproductive organs are preserved. I suppose we have 30 or 40 of these ferns now. Ferns once thrown together under the common name of *Sphenopteris* we now know belong to groups as widely apart from each other as they could well be. There is a pretty little *Sphenopteris* found in Scotland—which has been identified with one named by Brongniart. It happens, however, that this Scotch specimen has the organs of fructification of a plant which is not a true fern, but one of the aberrant group of the Marrattiaceæ. These plants have organs of fructification altogether different from those of the great bulk of the ferns—so different that they constitute now an independent group, just outside the ferns. It turns out that this little *Sphenopteris* has the organs of fructification of Danæa, one of these Marrattiaceæ. Having now got the fructification, we can see what an utter mistake has been made in calling this plant a *Sphenopteris*. Let me mention one point more. If we trusted to foliage alone, we should ordinarily find no difficulty in distinguishing a fern from one of the cycads, or from one of the pine tribe; but if we were ignorant of a fact I wish to state, we should again fall into blunders. The great mass of the ferns have one kind of nervation—(Professor Williamson illustrated this

by a drawing on the black board of a fern frond, showing the difference between its nervation and that of the more highly organised Cycads). One would think that such a fern leaf (shown in the drawing) could easily be distinguished from the ordinary leaf of a Cycad. You would say there is no possibility of confounding a fern with a cycad. But nearly 50 years ago, when the expedition went out to the river Niger, my old friend, now dead, Dr. Stanger, discovered a living Cycadean stem bearing a regular Cycadean cone, hence a plant belonging to the Gymnospermous group; but on examining its leaves we found that it had the foliage of a fern, and no one who had found a frond of the *Stangeria*, (as the new plant was named after its discoverer) in a fossil state, could have distinguished it from that of a fern. He would have fallen into the mistake of putting it in a place altogether foreign to its true relations; yet, with all these difficulties and obscurities staring us in the face, some people have no difficulty in telling us the exact genealogy of the vegetable kingdom. But when more cautious and practiced men look behind the scenes, and see how far these pedigrees correspond with proven fact, they find them very much like many other pedigrees—which will not bear investigation. I venture to dispute the authenticity of those vegetable pedigrees. Certainly the day is not yet come when the primæval ancestors of living vegetation can be traced. Let us go back to the Devonian age. We can show that Conifers then existed, associated with arborescent calamites, gigantic Lycopods and other forms; but when we ask, Whence came all these highly organised plants? What was there before this Devonian age? Nature makes as yet no response. She has nothing to tell us. A few odd spores and other vegetable fragments alone have been found in rocks older than the Devonians, but in

the latter rocks we have this Cryptogamic vegetation associated with representatives of the Pines and Cycads, without a guide of any kind as to what even their immediate ancestry was. Now if you take up any work on botany, you will see what an enormous array of plants you have of lower organisation than these; yet, according to Darwinism, representatives of these lower plants ought to have existed in those early days. These grand plants found in the Devonian rocks must have had ancestors, and if we could go far enough back we should find they primarily sprang from the simplest forms, just as other living plants spring from a cell which grows in the interior of its seed or its spore. Yet in the face of all these insuperable difficulties, arising from our absolute ignorance of the facts, men are still to be found framing Botanical pedigrees—Will-o'-th'-Wisps—that can lead to no useful end.

A vote of thanks to the authorities of Owens College for the permission to meet in the Mineralogical Museum, was passed unanimously, and brought the meeting to a close.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XVIII. SESSION 1884-85.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, February 3rd, 1885, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

Professor W. BOYD DAWKINS, F.R.S.,
in the Chair.

Mr. THOMAS WARD, of the Salt Works, Northwich, was balloted for and duly elected an ordinary member of the Society.

The following are the recent additions to the Library:—

Campi Phlegræi: Observations on the Volcanoes of the Two Sicilies; by Sir William Hamilton, 2 vols., text and plates.—*Presented by Henry Wilde, Esq.*

Brighton Corporation Waterworks: Pamphlet by Edward Easton, C.E.—*From W. Whittaker, F.G.S.*

On the Area of Chalk as a Source of Water Supply; by W. Whittaker, F.G.S.; pamphlet.—*From the Author.*

Geological Report on Londonderry and parts of Tyrone and Fermanagh, by J. E. Portlock, F.R.S.—*Presented by W. Whittaker, B.A., F.G.S.*

Chesterfield and Derbyshire Institute of Engineers: Transactions, Part 11, Vol. XIII.—*From the Institute.*

Dundee Free Library: Report of Committee, 1884.

Edinburgh Royal Physical Society: Proceedings, Session 1883-4.—*From the Society.*

Leicester Literary and Philosophical Society: Report of Council and Transactions, 1883-4.—*From the Society.*

Leicester Town Museum: Tenth Report, 1884.—*From the Committee.*

Liverpool Science Students' Association, Session 1883-4.—*From the Association.*

London: Geological Magazine, Nos. 246-8.—*Purchased.*

Ditto, Illustrated Science Monthly, No. 14, December, 1884.—*From the Editor.*

Ditto, Geologists' Association, No. 7, Vol. VIII.—*From the Association.*

Ditto, Royal Society, Proceedings, No. 234, Vol. XXXVII.—*From the Society.*

Ditto, Institution of Mechanical Engineers, Proceedings, No. 4, 1884.—*From the Institution.*

Ditto, Iron and Steel Institute Journal, No. 11, 1884.—*From the Institute.*

Ditto, Palæontographical Society, Vol. XXXVIII., 1884.—*Purchased.*

Mining Institute of Scotland: Transactions, Parts 6-7, Vol. VI.—*From the Institute.*

Peacock, R. A.: Saturated Steam as Motive Power in Volcanoes; pamphlet.—*From Author.*

Salford Museum, Libraries, and Parks Committee: Thirty-sixth Annual Report, 1883-4.—*From Committee.*

Canada: Descriptive Sketch of the Physical Geography and Geology of Canada, by Dr. Selwyn and Dr. Dawson.

Ditto, Comparative Vocabularies of the Indian Tribes of British Columbia, by W. F. Tolmie and Dr. Dawson.

Ditto, Two Maps of the Dominion of Canada.—*From A. R. C. Selwyn, F.R.S., Director of the Survey.*

Ditto, Hamilton Association, Journal and Proceedings, Part 1, Vol. I.—*From the Association.*

U.S.A.: Harvard College, Annual Report of the Curator of the Museum of Comparative Zoology, 1883-4.—*From Alexander Agassiz.*

Harvard College, Bulletin of the Museum of Comparative Zoology, Vol. I.-VII., Geological Series, Nos. 2 to 8, No. 11, with Index.

Paris: Revue de la Legislation des Mines, December, 1884.—*Purchased.*

Ditto, Les Roches, by Ed. Jannetaz.—*From the Editor on behalf of the Author.*

Ditto, Paléontologic Francaise, par S. Meunier.—*Ditto.*

Lille: Société Géologique du Nord, Annales XI., 1883-4.—*From the Society.*

Petersburg: Geological Committee, Institute of Mines, Part 1, 1882; Parts 1-7, 1883, Parts 1-9, 1884.

Ditto, Mémoires du Comité Geologique, Nos. 1 to 3, Vol. I.

Petersburg: Academie Impériale des Sciences, Bulletin, Tome XXIX., Parts 2-3. Mèmoires, Tome XXXII., Parts 4-12.—*From the Academy.*

Roma: Atti della Società Toscana di Scienzi Naturali. Processi Verbali, Vol. XIV., December, 1884. Transunti, Vol. VIII., Fasc 16 to last.—*From the Society.*

Victoria: Report of Mining Registrars for the Quarter ending September 30th, 1884. The Gold Fields of Victoria.

THE APATITE DEPOSITS OF CANADA.

The CHAIRMAN said the next business before the meeting was a paper "On a possible Genesis of the Canadian Apatite," by Mr. G. H. Kinahan; and he thought perhaps it might be convenient to take, in connection with it, the "Notes on Professor Dawkins's paper by Mr. G. A. KINAHAN." It was evident that the paper read at a former meeting had been the means of getting a considerable amount of information for the Society on that rather interesting subject.

Mr. MARTIN read Mr. G. H. Kinahan's paper:—

ON A POSSIBLE GENESIS OF THE CANADIAN APATITE.

BY G. HENRY KINAHAN, M.R.I.A., &c.

In an inquiry of this nature it appears expedient to establish a known basis to which reference can be made; we will select the Irish Lower Palæozoic rocks, as with them our knowledge is more intimate than those of elsewhere, and at the same time compare phenomena observed in Canada with those studies among them.

From my brief explorations among the Canadian rocks, it appeared that the apatite rocks, but especially those rich in the mineral, were confined to a band or group of a limited width; this being made up of an association of various eruptive rocks both in beds and protrusions, calcareous rocks

of different kinds, and schists; among the latter there being subordinate quartzytes, while more generally they were micalytes, talcytes, chlorilytes, or such like. The eruptive rocks that specially belonged to the group seemed for the most part to be more or less basic; such as granitone, diabase, gabbro, and the varieties of euryte (*Daubuisson*), or the hybrid rocks of *Durocher*. There are, however, protruding into these rocks different granitic rocks, also rocks apparently much younger, such as the dyke in the heave line at the Emerald Mine, in the vale of the Du Lièvre.

Some poorer apatites occur in beds as apatitic schists; similar accumulations have elsewhere been called *dradge lodes*.* The rich accumulations, however, occur in true lodes having two walls, in lodes with one wall (half lodes), in bunches, lay and lay, and as string or small irregular veins.

The true lodes appear nearly invariably to have selvages at both walls, either a flucan (steatitic clay) or a steatitic schist, in part they have a comb structure, but more generally the apatite appears to fill the fissure; but having scattered through it minerals, the more conspicuous being stacks or crystals of blackish mica and veins of pyrrhotite.† In one lode was observed a vein of quartz (*cab*), which appeared to be more or less parallel to the walls, and associated with it were crystals of various minerals. Some lodes, or portions of them, seemed to be typical "dradge lodes;" but at the same time there did not appear to be any "vein-stuff" that could be classified as a regular typical "gangue;" in some deposits, however, especially the

* Coppery schists in West Cork have been called "dradge lodes." This Cornish term, however, I believe, ought correctly to be confined to a true lode, in which the mineral occurs as specks or spots irregularly in the vein-stuff.

† This has very much the appearance of nickeliferous pyrrhotite, but in the specimen brought home none was found.

bunches, limestone came in, more or less irregularly, the apatite graduating into limestone; while in the latter were apatite crystals, some of great size, the largest known at the time (August, 1854,) being 800 lbs. weight, as exhibited at the office of the *Mining Review*, Ottawa.

The half lodes may have either a foot, or a hanging wall with a selvage; near which the ore appears to be richest, the veins as it recedes from it becoming dradgy, and eventually merging into the country rock. It should be mentioned that the country rock outside the walls of both the true lodes and also the half lodes may be more or less apatitic. From the state of the working it cannot be satisfactorily seen whether the ore in the lodes occurs as *courses* or *shoots*, but it probably occurs in both ways.

Some of the bunches occur in connection with the lodes, they having accumulated in "vugs" that joined into the lode; others, however, seem to be independent accumulations. Of the latter some are in more or less regular masses, but others send of, or break up, into irregular branches or veins. The "lay and lay," as with other minerals, occur as layers in the planes of the stratification or the structures; while the strings and small irregular veins are like those filled with other minerals. From the foregoing it will be seen the deposits of apatite are more or less like those of galena in some limestone districts; while they are also like some of the accumulations of limestone dolomite or allied rocks in the Lower Palæozoic rocks of Ireland, as will be presently mentioned.

The "back" or "gossan" of the apatite lodes is ferriferous; probably principally due to the decomposition of the pyrrhotite and mica; the "gossan-colour," however, has peculiarities of its own, being somewhat like that of a coppery gossan, but at the same time quite distinct. It is very hard to describe it in words, more especially as in my

experience I have scarcely met two persons who see colours similarly. It is, however, like the *buæ* colour of the Irish; that is, a mixture of yellow and brown with a purplish tinge. As far as I could see, the "back" seems to be usually sandy, sometimes clayey; in depth becoming more purplish, due to it being mixed with apatite sand*: while on the back of a bunch the "broken" and "hard shelf" are stained more or less with the typical "gossan-colour." A good knowledge of the gossan-colour and the nature of the back seems to be of great importance to the explorers, as on account of the frailty of the mineral the backs of the lodes are of more or less depth; while many of the bunches seem not to come to the surface, and their position must be guessed at by the colouring of the broken and hard shelf.

That the Archæan Rocks of Canada are to be separated from other metamorphic rocks and are to be supposed to have accumulated in their present crystalline states, appears quite unnecessary, as they make and are similar to other metamorphic rocks of various ages. In that little bit of the earth called Ireland, are found rocks identical with the majority of these Canadian rocks; which can be demonstrated to belong to the Cambrian (Primoidal), Cambro-Silurians (Ordovician), and Silurians. Neither does it appear necessary to insist that lithological characters, not even when they are also accompanied by a distinct break, constitute a petrological or stratigraphical boundary; as portions of the rocks of a group may be more altered than others, while a protrusion of granite or any other exotic rocks, when altered along with those associated, will have a hard boundary, and probably will appear as if

*The upper portion of the apatite lodes under the back, or what would be called in a copper or sulphur-ore mine the "gossan lode," seemed to be a cemented or re-arranged purplish apatite sand, in which are irregular crystalline pieces of the green variety.

older, while in reality the original protrusion was younger than the rocks which it now underlies.

In the Croaghan-Kinshelagh district, Counties Wicklow and Wexford, Ireland, there are rocks that have been subjected to a more recent period of metamorphic action than any that invade the adjoining rocks, the results being that these rocks are now as much altered as many of the Canadian Archæan Rocks; yet petrologically they belong to the uppermost or youngest Cambro-Silurian strata—rocks which some few miles to the N.E. are unaltered. In Ireland we can also see the relations between metamorphosed protrusions and their associated sedimentary rocks; good examples being exposed in the Slieve Croob district, County Down, and the Castlebar district, County Mayo, where there were protrusions of granite that are now altered into gneiss*, having hard boundaries between them and the associated metamorphosed sedimentary rocks. As already mentioned, in the Archæan gneissose rocks of the Ottawa county, there is a band or group of strata made up of schists, eruptive rocks, and varieties of calcareous or allied rocks; in it the valuable accumulations of apatite have been found, and the well-marked characters of this group are more or less analagous to those of bands or groups in Irish Lower Palæozoic rocks. Of the latter the best marked group is the middle division (*Eruptive series*) of the Cambro-Silurian, as seen in south-east Ireland (Counties Waterford, Wexford, and Wicklow). Here it consists of eruptive rocks in bedded masses and protrusions, tuffose rocks, calcareous and dolomitic rocks, argillytes, micalytes, talcytes, with subordinate quartzytes, and metalliferous schists; such as pyritilytes, graphityte

* This gneissic granite of County Mayo is more or less similar to the Labradorian or Norian gneiss of Eastern Quebec, and other Canadian localities. The protrusions however are mere specks in comparison, as some of the Canadian protrusions are larger than any of the Irish provinces, or perhaps of the whole of them.

and calcareo-ferriferous schists. The eruptive rocks are in a great measure similar to those in the vale of the Du Lièvre, Ottawa county, except that paramorphosis has more altered the latter.

In the S.W. of Galway and the S.W. of Mayo these rocks also occur *(Lettermullen* and *Croaghpatrick beds)*; but in these places the bands are of less width, while the rocks are not as well exposed; those seen are however more similar to the Canadian rocks, being more altered.

There are also in West Galway two other bands of more or less similar rocks; one, the younger (highest strata in the *Great Micalyte series*), being the uppermost member of the group of rocks that appear to be the equivalents of the Arenig rocks (Upper Cambrian) of Wales; while the older is a group in the supposed Lower Cambrian (*Ophiolyte* and *Dolomyte series*). In the latter there are some peculiar calcareous or allied rocks, exactly similar to some of those met with in the Vales of the Du Lièvre and the Gatineau. In the Co. Donegal there are also similar bands, but of even less widths; they however are interesting on account of the rocks in them. The exact age of these is not yet satisfactorily worked out, but in the "Geology of Ireland" it is suggested that they are probably of Cambrian or Cambro-silurian age.

Certain limestones and dolomites, in these groups of rocks in S.E. Ireland, Galway, Mayo, and Donegal, also in other Irish localities that need nôt now be specially enumerated, are very curious, entangled in, and associated with, basic eruptive rocks [*Gabbro*, *Granitone*, *Euryte* (Daubuisson) or *Hybrid rocks* (Durocher) and allied rocks], also with quartzytes and greissen *(quartz-rock* or *reef-quartz)*. This connection of silicious and calcareous rocks with eruptive rocks induced me some years ago to suggest that they were probably adjuncts of vulcanicity *(Geology of Ireland, chap. XII. and XIII., and prior papers)*; while, since then,

subsequent explorations seem to add strength to the suggestion, as rocks of these kinds occur in such intimate relations to eruptive rocks, that they could not be ordinary sedimentary accumulations, but must have come into their present position in solution, or have been injected therein; the first, however, is more probable than the last.

The similitude between the Irish association of rocks, if the limestone was replaced by apatite, and those in the Vale of the Du Lièvre forcibly presented itself when the latter was first seen, while subsequently, examination strengthened it.* An examination of the "backs" of the lodes and bunches exhibited a colour similar to that of rocks, which, in Ireland, give indication of the presence of phosphoric acid, although in some cases very faint. This seems to suggest, considering the relative state of the rocks, those of Canada being more metamorphosed than the Irish ones, that there might be an affinity between them; while further examination and consideration appear to strengthen the impression.†

* Regular lodes of dolomyte and calcite occur in Irish eruptive rocks; also veins of bastard limestones, with *one wall* merging at the other side into the country rock,—such lodes and half-lodes that I call to remembrance are however mere bagatelle to the Canadian lodes of apatite. But Ophyte is a paramorphosis of igneous rocks, while Ophiolyte is the paramorphosis of calcareous rocks; and associated with both, but especially the latter, are allied "vein rocks," such as Pyroscleryte, Chonikryte, Loganyte, Selwynyte, &c. As such "vein rocks" are common adjuncts of allied rocks, similar veins might be expected to be found associated with the Serpentines and masses of apatite, if apatite is also a result of paramorphosis. Thus the apatite lodes may be possibly "normal lodes," *i.e.*, fissures filled with materials from solution. I may mention that on Achill Island, county Mayo, there is an accumulation of very pure steatyte, apparently due to deposition from solution.

† Phosphoric acid in small quantities is frequently found by chemists in limestones and dolomytes. It would, however, be necessary to know the exact localities where such limestones and dolomytes came from in order to determine whether the rocks were an ordinary deposit or subsequently partially altered. This is an important point; as unless special localities where such apatite limestone came from is known, they ought not to be brought in as evidence "that many limestones contain apatite."

It should also be mentioned that in some of the Irish eruptive rocks, which apparently belong to those called *Euryte* by Daubuisson or the *Hybrid rocks* of Durocher; there seems to be small quantities or traces of phosphoric acid*. This appears to be an important consideration, as will be presently mentioned.

The inquiry in connection with the home rocks is as yet far from being complete. After I learned the "gossan colour" of the apatites, which was previous to my going to Canada, I have not had an opportunity of examining any but submetamorphic rocks, in which the pyroxene is little if at all changed; while according to the researches of G. H. Williams, of Baltimore, in the associated eruptive rocks of the apatites of the Vale of the Du Lièvre, and also in Scandinavia there is a paramorphosis of the pyroxene and the felspar, the first "being more or less changed into hornblende and the latter into wernerite." Nevertheless, the home researches, up to the present, appear to suggest that in the Irish submetamorphic rocks there has been a limited paramorphosis of limestone into apatite.

From what has been observed in Canada and in Ireland, I would venture to suggest that *it is possible the present Canadian apatites were originally limestone or allied rocks, the change to apatite being due to paramorphosis, which at present cannot be satisfactorily explained.* Such a suggestion seems allowable, when we consider that the paramorphosis of pyroxene into hornblende, although known to take place, cannot as yet be explained. An objection that may be raised is,—Where did the phosphoric acid come from? If, however, it can be satisfactorily proved that in some or many of the unaltered Irish eurytes this acid is present, this objection would in a great measure be answered. Because if in the Irish assembly of submetamorphic rocks there are found

* These rocks weather with a partial gossan colour of the Canadian apatite.

phosphoritic eruptive rocks and limestones associated, while in the Canadian metamorphic rocks apatite and non-phosphoritic eruptive rocks are similarly related, it may be supposed that the additional action to which the latter were subjected was such as to allow the phosphoric acid to replace the carbonic acid.

In addition to the similitude between the form and occurrence of the limestone and apatite, there are other circumstances that may add weight to the previous suggestion, besides showing that other characteristic minerals of Canadian Archæan Rocks may be also the products of metamorphic action. Not however to excessive metamorphism, that is, an excessive change that took place at one time, or in one period of time; but to successive alterations, due to invasions of metamorphic action, with intervals of greater or less duration between each. Rocks of such a great age as the Laurentian would necessarily be subjected to such vicissitudes; as during the lapse of time since they were first accumulated, they must sometimes have been at great depths below the surface of the earth, while at other times they were at or near it; therefore it appears safe to conjecture that the change they underwent during the first period of metamorphic action was subsequently augmented by the action of latter periods. Artificially, graphite can be produced by heat, so also can specular iron ore; if therefore in the Canadian rock, when submetamorphic, there were graphitytes, pyritilytes, pyrrhotilytes, with ferriferous limestones, and schists, as found in the Irish rocks, there would have been rocks that, by subsequent alteration, should change into the graphite-schist and other graphite producing rocks, the "specular schist" and other iron ores; while it might be also suggested that the metamorphosis of pegmatyte would further develope its minerals, and by concentration increase the size of each individual mineral;

thereby accounting for the great size of the crystal of mica and other constituents of the Archæan pegmatytes.

It may appear presumptuous in a person, not a chemist, to put forward some of the above suggestions, still, as during the last six or eight years I have been studying the possible or probable genesis of apatite, they may be excusable. Besides, from my knowledge of Irish rocks, and also of rocks in a few English and Scotch localities, I suspect, now that special attention is directed to the subject that apatitic rocks will be discovered in different localities; nor would I be surprised if some of them were of commercial value.

The following notes by Mr. GERARD A. KINAHAN, of Camborne, Cornwall, was next read :—

NOTES ON PROFESSOR BOYD DAWKINS' PAPER, "APATITE DEPOSITS NEAR OTTAWA."

(Read at previous meeting, *vide* Part 3, Vol. 18, page 47.)

Mr. GERRARD A. KINAHAN.

(Communicated through the Hon. Secretaries.)

I have read with considerable interest Professor Dawkins' valuable paper on the occurrence of the phosphate, but his remarks as to the origin of the deposit at the Emerald mine are, it appears, not quite conclusive. The precise origin of these deposits is difficult to conceive; they are not sufficiently regular in structure or direction for lode, or fissure deposits, nor are they continuous enough for bedded masses, unless it be that the original bed—of limestone say—became greatly contorted and broken up, or possibly pinched through in places, on the plication of the strata while undergoing intense metamorphism.

From a cursory examination of the deposit at the Emerald mine in the fall of 1883, it appeared to me that the phos-

phate occurred in a partially altered limestone bed; the alteration having been most complete on the upper side, but had gradually invaded its lower portion; athwart this bed there were apparently smaller veins of segregative or secondary origin.

The main bed had then essentially the same structure as described in the paper, except that the apatite crystals were more numerous towards the junction of the calcite and the massive deposits of apatite. The bed dipped south at about 75°; on the south or hanging wall the apatite was massed; to the north lay the calcite or crystalline limestone; but about two feet beyond or under what appeared to be the foot-wall or base of the bed, phosphate was reported to occur again; this had not been opened upon.

The apatite crystals penetrating the limestone were very perfect, many doubly terminated, and some very massive; they appeared to have been introduced, or to have grown subsequently into the calcite, similar to the growth of magnetite crystals, or iron-pyrites crystals in fine slates and shales. Many of them contain enclosures of calcite, which are always more or less spherical, as though squeezed by the growth of the enclosing crystal. Almost perfect, large crystals of pyroxene also occurred in the calcite; one specimen measured 4in. by 1½in. by ¾in. The bed appeared to be much wider in depth than at its outcrop, where apparently weathering had allowed the country rock to close in over it.

In a deep and wide cut run in from the west, to open up the deposit, a vein, about two feet wide, and dipping north (across the bed) at about 60°, showed in the face of the working; it had a "lody" structure, and contained specimens of galena, zinc-blende, copper and iron-pyrites. In the centre there was a rib of selenite two inches wide; on the under side of this vein, phosphate was more plentiful than above.

It is difficult to correlate the phenomena at the Emerald mine with either ordinary segregation veins or true lode deposits. In segregation veins the filling materials are chiefly the constituents of the adjoining rocks, and largely crystallized. In this deposit the mica is almost the only mineral that can be said so to occur. From a deposit in a true fissure vein, that of the Emerald mine differs both in composition and structure.

The contents of the vein—exclusive of the apatite and calcite—both in quantity and variety of minerals, are comparatively limited; and except in the case of the metallic sulphides, are not those of true lodes. Quartz in particular is notably absent. Specimens do occur, but they are not abundant. The dearth of fluorite is remarkable; it occurs mostly intimately intermingled with the phosphate; but as a separate species it is not plentiful. The occurrences of calcite in these rocks in such quantities as a gangue is exceptional. Calcite as a gangue in fissure veins mostly accompanies lead ores, especially in limestone rocks. It does occur in fissure veins in other rocks—as granite—but is generally subordinate to the barytes, quartz, or spar gangue.

In structure the deposit does not resemble that of a true lode or fissure vein. There is an absence of continuity in any particular direction, and in cross section there is no correspondence between deposits on opposite sides, calcite occurs on the foot, apatite on the hanging wall. If these deposits occurred simultaneously, what could produce this separation? If at separate times, the first to deposit should occur on both walls.

On account of the absence of the more common phenomena of mineral veins, it appeared to me that this deposit had resulted from the action of a solution bearing fluorine and phosphorus (in what combinations it is impossible to say) on

a bed of limestone, and that the "lody vein" previously mentioned was the channel through which this solution had access; and that the transverse veins were small fissures in which this solution re-acted upon a calcareous one. This latter phase (the transverse veins) is more marked at the Victoria mine (Gore); but there much of the phosphate appeared to occur in a large pegmatite dyke. The same is, I believe, the case at the High Rock mine.

DISCUSSION.—Mr. Dickinson said: When Professor Dawkins read this paper, at the December meeting, he (Mr. Dickinson) was anxious to ascertain where the principal places were, in Great Britain, where such deposits were likely to be met with; and from what was then elicited it appeared that the veins were situate in the quartzite and the limestone (p. 58). Now he noticed in Mr. Kinahan's communication, there was a statement that unless the special localities where such apatite limestone came from are known they ought not to be brought in as evidence that many limestones contain apatite, and he noticed also, in Mr. Kinahan's paper that "rocks especially rich in this mineral are confined to a band or group of limited width made up of an association of various eruptive rocks," &c. Then he said: "There are protruding into these rocks different granitic rocks, also rocks apparently much younger; and the poorer apatites occur in beds and apatite schists. The rich accumulations occur only in true lodes having true walls." The rocks here mentioned were those referred to by Professor Dawkins in his paper as Archæan. In this, therefore, Professor Dawkins and Mr. Kinahan were agreed; there was only that slight difference with regard to the limestone upon which, perhaps, Professor Dawkins would be able to throw some further light.

Mr. Stirrup observed that Professor Dawkins, in his

description of the apatite mines of Canada, said that they throw light upon the history of mineral veins in general, and with that statement he was quite disposed to agree. He noticed what he thought was a little discrepancy in Professor Dawkins's remarks. On page 52 he said that the rocks traversed by the veins contained apatite; then, subsequently, on referring to the probable origin of apatite, he said the surrounding rocks did not possess such a material as apatite. The latter remark was apparently in answer to his (Mr. Stirrup's) suggestion that the apatite might have found its way into the veins from the rocks by means of solution. Professor Dawkins also looked upon apatite "as a mineral, filling veins exactly like lead, silver or gold;" and that was the way he (Mr. Stirrup) looked upon it—that those apatite veins are filled exactly as other mineral veins were filled—but he did not hold the same opinion as the Professor that the apatite was derived from some deep-rooted source. He thought it might be found, if the rocks were properly analyzed, in the rocks themselves through which the veins ran. David Forbes, the well-known petrologist, found that in some of the Silurian and Cambrian limestones of Norway phosphoric acid was present in minute quantity. It was only wanted in minute quantity to account for its presence in those veins, because the veins were only found in the Archæan rocks; and those rocks must have been subjected to a large amount of metamorphism to find them as they were at the present day. There was, he thought, no doubt that apatite occurred as an original constituent of the rocks. He did not see any reason why we should seek for a source of apatite from the interior of the earth, rather than from some unusual case of metamorphism, or—to use Mr. Kinahan's words—paramorphosis. In Ireland, said Mr. G. H. Kinahan, the rocks are identical with the majority of the Canadian rocks. The Irish rocks can be demonstrated

to belong to the Cambrian, Silurian, and Cambro-Silurian series—rocks much later in age than the Archæan rocks, therefore, other things being equal, not likely to have undergone the same amount of metamorphism as their Canadian representatives. Mr. Kinahan, sen., evidently agreed with Professor Dawkins with regard to the occurrence of the apatite in *veins*, yet Mr. Kinahan, jun., who had visited these apatite mines, was of a contrary opinion and believed that the deposit of apatite was due to chemical action upon a *bed* of limestone. Mr. Kinahan, sen., seems also to support this latter view when he suggests "that the present apatites were originally limestone, or allied rocks, the change to apatite being due to paramorphosis which at present cannot be satisfactorily explained." Upon this and other points it would be observed the authorities did not agree. He was, however, glad that the papers had been brought forward, as it induced discussion upon a subject of great interest.

Professor DAWKINS said he felt very well satisfied with the result of the short paper which he laid before the Society in December. They were fortunate in having had papers from Mr. G. H. Kinahan and his son, the former of whom, he had much satisfaction in learning, was on the look-out for localities in Ireland where it was likely that valuable mineral (apatite) might be found. With regard to the points of difference between Mr. Kinahan, *père*, and himself, they were so microscopic that really it was hardly worth while alluding to them. He did not think that Mr. Kinahan had thrown very much light upon the subject by suggesting that apatite was metamorphosed limestone. He did not see that he could assign any other possible source for the phosphoric acid than that they were already aware of. With the evidence before them regarding the distribution of apatite in the crystalline rocks—(for they found it in the granites and in certain igneous rocks, which had come deep

down from below)—and when they found it in other rocks which had been profoundly altered, his view, that apatite came from below rather than from above, was very much nearer the truth than that it was the result of changed structure in the sedimentary rocks, which had been altered by the action of intense heat. The consideration of that point led him to touch the question raised by Mr. Stirrup as to the apparant discrepancy between a portion of his paper and his subsequent remarks. He said in one part of his communication that the apatite crystals did occur in the associated rocks; and he said in another part that he thought it was very improbable the apatite could have been derived from the rock of the district, because the original constituents of those rocks—which are now altered into mica schists and gneisses, and the like—were originally sand banks and mud banks. The sedimentary rocks, out of which these highly-altered crystalline and semi-crystalline rocks were found, did not contain any appreciable amount of phosphoric acid. The apatite in the altered rocks must, in his opinion, have been derived from the same source as that in the mineral veins. The same amount of heat and pressure which would cause the water to dissolve and to deposit the apatite in the vein, would also cause the water to traverse the rock and deposit the apatite crystals in it. The finding of apatite crystals in the neighbourhood of a vein did not tell them anything at all about the origin of the apatite. Nor did he think that by applying any amount of microscopical research to the rocks in the immediate neighbourhood of the mineral veins would they be enabled to get any information as to the source of the minerals. With regard to Mr. G. A. Kinahan's communication, he could hardly agree with him as to these not being true lodes; and he certainly thought such a condition of things as that described was only to be accounted for by the

fact of its being a true lode. The question was one of great economic value in that part of the country, as most of the workings had, up to the present time, been carried on on the hypothesis that the veins were not true lodes. He could not look upon them as other than true lodes of the ordinary character. With regard to these lodes being confined merely to one narrow belt of country, he was not quite clear that that was so. He was not in a position at the present moment to say anything definite about it, but from his recollection of the map shown him by the officers of the Geological Survey, of the apatite region, it was not a narrow band but rather a series of broad mineral districts extending over an area of many miles.

Mr. Burnett observed that Mr. Kinahan, in his paper, suggested that the limestone had been metamorphosed into apatite. He (Mr. Burnett) would like to know whether there was, in the pre-Cambrian rocks, or the Silurian, or the more recent limestone, any evidence of such metamorphosis. If there had been such evidence he thought it would have been forthcoming. He was bound to say that Professor Dawkins had the greatest amount of evidence on his side.

Mr. Dickinson: As regards the metamorphosis of a certain kind of rock into one of a different kind, we have many instances of it in different kinds of minerals; but I am not aware that we have it as regards apatite. For instance, it is not uncommon to find limestone changed into a very good ironstone where the mineral vein passes through it. There may be similar changes as regards apatite, but the good of these papers will be to let us know where to look for this valuable mineral.

The discussion was then closed, it being understood that the subject would be re-introduced in the event of further communications being received.

DISCUSSION ON MR. DE RANCE'S PAPER "ON BRINE IN THE COAL MEASURES."

(Read at previous meeting, *vide* Part 3, Vol. XVIII., page 61.)

Note from Mr. W. S. GRESLEY, F.G.S.

(Communicated through the Hon. Secs.)

The salt spring stated (on page 65) to be issuing at the surface at Donisthorpe, in Leicestershire, has long since ceased to flow. Some 20 or 30 years since, a colliery shaft was sunk in the district, and it was then that the salt spring disappeared altogether. This spring was not in Leicestershire, but in the county of Derby.

The brine at Moira Colliery has been pumped from the Main Coal seam at 750 ft. deep at the rate of some 13 gallons per minute for about 70 years. Until quite recently, it was used at Moira and at Ashby-de-la-Zouch for baths. The bulk of the water appears to come from the Main Coal itself, though it exists in the measures both above and below it. The coal seams at 80 to 100 yards beneath are impregnated with salt-water. It seems rather a singular thing, but I believe it is, nevertheless, a fact that the water, though so much pumped out, loses none of its former strength or healing qualities, neither does the quantity appear to diminish; notwithstanding, the exhaustion of the coal goes on at an ever-increasing rate. I know of no rock-salt deposits anywhere in the neighbourhood, from or through which the water could have become brine and afterwards found its way into the coal measures. In fact, it is clear that the salt-water exists *in* the coal itself.

In this same coal-field (Leicestershire and South Derbyshire) at the Netherseal Colliery, where the coal is overlaid by the Permian and Triassic beds of over 100 yards in thickness, a feeder of water broke in in June, 1884, and has continued to flow at the rate of 50 to 60 galls. per minute

ver since. Now this water has a strong sulphury smell, ut is clear and cool. It broke in suddenly when the first weight" came on in some long-wall stalls. I under- tand no "gob-fire" had existed in the district which could ave imparted a smoky taste and smell to it; and it is uncer- ain whether the spring comes from the floor or from the oof, as it broke in in the goaf.

It may be of interest to the members to know that in outh Staffordshire, at No. 2 pit, Cannock Chase Colliery, alt-water was met with in the sinkings at 255 yards deep. his was in a stratum of *Conglomerate of Hæmatite nodules.* . little lower down in the same shaft, viz., at 272 yards, rine to the quantity of 700 galls. per hour was struck· his was in a *hard brown grit rock.* Still deeper, in a *ndstone* at 330 yards, salt water was found. These springs re only a few yards above the *Silurian beds* which were roved in the same shaft.

I think I am right when I say that I recollect tasting *lt water* at the depth of about *935 yards* in the Ashton loss New Winning, which was "bleeding"* from the coal.

The HON. SECRETARIES reported that a letter had been eceived from Mr. De Rance regretting his absence, and ontaining the following paragraph from a letter which he ad received from Dr. Percy, F.R.S., in reference to his ecent paper, and pointing out the danger of using water npregnated with saline matters for steam boilers: "You ill find a fact confirmatory of this in my volume on 'Iron nd Steel,' p. 511, published in 1864. I had an explosion rom this cause in the boiler of a small engine, which I put t the bottom of a pit 300 yards deep, and which was pplied with water from the "dip" of the pit. The olliery was called "The Oak," and was at West Bromwich,

*QUERY.—Issuing from rock in a tunnel between the 6ft. and 4ft. beds coal.—J. D.

South Staffordshire. The salt in the boiler was analysed, and found to contain 95 per cent. of chloride of sodium."

Mr. WATTS asked whether the collieries referred to by Mr. Gresley are below the level of the sea. I presume they are, but it is not so stated.

Mr. DICKINSON: I should think most of the collieries referred to are worked below the level of the sea; and, in addition to those Mr. De Rance has named, others might be cited. For instance, there is brackish water in the Pendleton colliery, and many others; but, although many geologists have laid down that all the Coal Measures are really of salt water formation, we do not find, in practice, that all the water found in the Coal Measures is either brackish or salt. I think that without drawing any hard and fast line, we might say that many collieries situated near the red marl formations have more salt in the water they contain than others which are at a greater distance from the marls. Pendleton, for instance, lies very near to these rocks; at Ashton Moss the ground is overlaid by the red rock formations; and the Birtley spring, to which Mr. De Rance alludes, is on the side of the valley of the Team, which contains a remarkable depth of sand that has puzzled a large number of geologists. I remember, when the British Association met at Newcastle-on-Tyne, it was brought forward by the late Mr. Buddle. It is a thick deposit—nearly down to 100 yards in depth—and it must have had its origin from one of the red sandstone rocks. I wish to throw out these hints, that a connection may exist more with the red marl and the red sandstones than has yet been considered to be the case. But this paper that Mr. De Rance has favoured us with is not confined to the subject of brine in the Coal Measures; it is a sort of *omnium gatherum*, containing a good deal of very useful matter. He gives abstracts, for instance, of some

borings in the Midland counties, which are of great value, rendering it unnecessary to wade through the Transactions of the Geological Society. I should like Mr. Ward, our newly-elected member, and a great authority on all questions relating to brine, to say a few words on the subject.

Mr. WARD: I cannot say much with regard to brine in the Coal Measures, because I am not at all acquainted with the Coal Measures. My acquaintance with brine and with rock salt has been more, as we find them in rocks of the Triassic formation in this country, although I have a general knowledge of rock salt all over the world. But there is one striking fact, namely, that up to the present moment not a solitary particle of rock salt has ever been found in the Coal Measures; nor do I think—I speak in the presence of abler geologists than myself—that the Coal Measures are a salt-water formation in any sense. It is not at all likely, or probable, that rock salt will ever be found in the Coal Measures. Salt water we may find, but it is weak and such as, in Cheshire, we should not call brine at all. It might be used in some districts in the absence of brine of the proper strength, but I do not think in any instance Mr. De Rance has specified a brine that would be worth working for the manufacture of salt. If it is derived from the rock salt at all, it must have travelled a long distance and have got mixed with the underground fresh water, for we never find the brine anywhere in the neighbourhood of the rock salt to be weak. It is generally strong, and we may get some idea of the distance of the rock salt from the brine by the strength of the brine itself. In America, rock salt is said to occur in rocks older than the Carboniferous—even as low down as the Silurian rocks—in Ohio, Virginia, and Pennsylvania. In Canada, also, the rock-salt beds are deep-seated, but, generally speaking, the great bulk of the rock salt and of brine is found in the rocks above the

Carboniferous formation. We have it on the authority of geologists who have studied the matter in the North-West of India, where there are enormous deposits of rock salt, that these are found in the Old Red, or even below it. That would take us very deep again; but, generally speaking, the brines that occur in Europe—all, I believe, with one or two exceptions, in Germany—have their rise in the New Red, or newer, formations still. In this country it is always so. I am inclined to think that the whole of the salt water found in coal mines has got there from the New Red Sandstones. We cannot tell how far it may have travelled nor whence it has come. There is a case, I believe, of a spring in Cumberland coming from the slate; it is a very deep-seated spring, and a very weak one. Whether the water gets in from the sea I cannot say, but I do not think sea water can travel very far without mixing with fresh water and becoming exceedingly weak. Mr. De Rance gave 4 or 5 per cent. as the proportion of salt in some of the Leicestershire springs—in others there is more—but, as a rule, you do not find more than 2½ or 3 (in extreme cases 4) per cent. If it had percolated through the rocks from the sea, I have no doubt it would have got mixed with fresh water, and by the time it reached Leicestershire there would be very little salt left.

Mr. BURNETT said he did not think Mr. De Rance, in his paper, led them to infer that there were beds of salt in the Coal Measures. He rather suggested that the salt had been derived from the land.

Mr. MARTIN said that in the collieries of Westphalia the water was almost invariably more or less brackish, although some hundreds of miles from the sea coast. On one occasion, being short of fresh water for the boilers, he had used the mine water with the result that in a very short time the boilers were lined with a coating of salt three or four

inches thick, in consequence of which the mine water had to be discontinued. At another point in the coalfield, about two miles north of the collieries then at work, a bore-hole was sunk to the Coal Measures, a depth of about 800 feet. It proved a regular artesian well, the water rising several feet above the surface. It was quite saline and considered to be good for various ailments, and was used as such. The colliery workings have since extended to that neighbourhood, and he presumed the water no longer flowed in the same manner.

Mr. WATTS said he was hardly prepared to accept Mr. De Rance's theory that the salt water found in mines came from the land. He had had experience of deep excavations in the carboniferous series, and also in the collecting of water from extensive drainage areas, but he had never met with any springs which yielded the smallest quantity of saline matter. He was sorry Mr. De Rance was not present to give them some further explanation in reference to that part of his paper.

Mr. STIRRUP said that everyone would allow that Mr. De Rance's paper was a very valuable one, and one that would be useful for future reference. As to the presence of water in mines, there could be no doubt as to the original source whence it came. It descended in the form of rain, filtered through the rocks to various depths, according to the porosity of the strata, and whatever soluble minerals it met with, in traversing the rocks, would be found in it when pumped up from the mine. Some persons had the idea that the salt found in the water of the Coal Measures was derived from the percolation of sea water through the rocks, others from the Coal Measures themselves. Mr. Gresley, in his notes, seemed to support the latter hypothesis. But he (Mr. Stirrup) rather agreed with Mr. Dickinson that the salinity could not have been

so derived, but that it was really due to a percolation of water through some deposit of salt, which was probably of Triassic age. Mr. Gresley spoke of the water found in one of the Leicestershire collieries as having a strong sulphury taste. That was not at all unlikely when it was considered that large quantities of iron pyrites were found in the Coal Measures. There was a paper by the late Mr. Molyneux (referred to by Mr. De Rance) read at one of the meetings of the British Association. Speaking of the Ashby-de-la-Zouch coal-field the author referred to the presence of marine shells, immediately above the Main coal, in shales covered by a bed of impervious clay; directly below these was an equally compact bed of fire-clay, and Mr. Molyneux's opinion was—owing to the presence of these marine shells—that the coal was a marine formation. He said: "The saline water of the coal is, in fact, the *fossil* or pent-up waters of the sea in which these animals lived whose fossil remains are found in the shales." That to his mind was an impossible idea. He could not believe the water now found in the Coal Measures could have been enclosed at the time these deposits were formed, and there retained until the present day.

Mr. MARTIN said that in sinking through the non-conformable strata overlying the Coal Measures of Westphalia, the green sand was met with 20 or 25 yards above the coal; yet the water found was not brackish. It was pure water down to that depth. Consequently it was in the Coal Measures themselves that the water had become brackish—whether through percolation through the measures, or otherwise, he could not say. But inasmuch as the Coal Measures there are much contorted, it might require some further investigation to say where it did come from.

Mr. DICKINSON: Over the salt beds of Cheshire it is not unusual to find beautiful spring water in the outlying sands.

Mr. MARTIN: But, as Coal Measures crop out a mile or two southwards, the presence of a bed of salt could hardly be an explanation of the presence of salt water in the Coal Measures.

Professor DAWKINS said he certainly agreed with Mr. Dickinson in his remark respecting the probable source of the brine found in the Coal Measures of this district. He believed in most cases it had come directly or indirectly—generally indirectly—from the stores of salt laid up in the red rocks of the Trias. It was impossible, in his opinion, that the conditions under which the carboniferous forests flourished could have been the conditions under which these beds of salt could be formed. He thought the Society had been fortunate in having such a discussion upon Mr. De Rance's communication. It was clear to him that the presence of brine in coal pits was by no means an exceptional thing. His conviction was that if they were to examine most of the waters in the deeper seated collieries, they would find very little pure drinkable water. In nine cases out of ten it would be found highly charged with various mineral solutions. Salt, he believed, was to some extent an exceptional product, and other saline materials were the rule rather than the exception.

Mr. GEORGE WILD reported that about October, 1863, after having sunk the Victoria shaft, at Bardsley, to the old and new mines, it was decided to work the former, which lies at the depth of about 1636 feet below the surface and is about 1218 feet below sea level. In driving the brow down to the downcast (Diamond shaft) after cessation of work for 36 hours we found an accummulation of about 40 gallons of water, which, on being cleared out, was found to be quite salty. My attention being called to it, I collected a quantity which tasted strongly and not disagreeably of common salt. I placed a small quantity, about half inch

deep, on a plate and evaporated the water, obtaining a residue of agreeably tasted salt covering the whole of the vessel to the depth of about $\frac{1}{16}$ of an inch. The measures dip towards the district where Triassic measures exist, but which are distant nearly two miles, and will probably be separated from this seam of coal by 4800 feet of variable strata. The shaft is also nearly 30 miles from the sea at its nearest point.

This concluded the discussion. The paper by Mr. Burrows, on "Accidents in Mines," was postponed till the next meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XVIII. SESSION 1884-5.

At the ORDINARY MONTHLY MEETING of the Members of the Society, held on Tuesday, the 3rd day of March, 1885, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

Mr. CLEGG LIVESEY, Vice-President,
in the Chair.

Dr. BLACK exhibited a block of grey chalk from the Channel Tunnel, near Dover, brought to the surface from the tunnelling operations. He also exhibited some photographs, showing the site of the works relative to the railway and the cliff, etc., as well as the locality of Shakespeare's Cliff, near which the tunnel shafts have been made.

Mr. STIRRUP mentioned that the subject of the Channel Tunnel was brought before the Society by Professor Dawkins, in a very interesting paper, about two years ago.

Mr. MARTIN: The specimen was just now interesting, as Colonel Beaumont had one of his boring machines at work in one of the Bridgewater collieries in this district, and in comparing the work effected by the machine at the Channel Tunnel, the Mersey Tunnel, and the Bridgewater Colliery Tunnel, the comparison of the various materials driven through would be important.

ACCIDENTS IN MINES AND THEIR PREVENTION.

By Mr. John S. Burrows.

Part I.—EXPLOSIONS.

There is no doubt that our abundant supply of fuel is the foundation of our national prosperity. An industry giving direct employment to nearly 515,000 persons, and raising in a year 178¾ million tons of such indispensable commodities as coal and ironstone, is worthy of a little more notice from the rest of the community than it sometimes receives. The melancholy fact that this magnificent result of man's industry and enterprise has been purchased at the terrible cost of 1,054 of our brave colliers' lives, besides injury to limbs, is the dark cloud on the picture, and no stone should be left unturned till this fatal record is reduced to the lowest possible point.

From the summary of the reports of the Government Inspectors of Coal and Ironstone Mines for the year 1883 we learn—

That 178¾ million tons were raised;
„ 514,933 persons were employed;
„ 1,054 lives were lost;
One life being lost for every 169,605 tons raised;
or „ „ 488 persons employed;
or 2·046 lives lost per 1,000 persons employed.

The average for the 10 years from 1874 to 1883, both inclusive, shows:—

One life lost for every 446 persons employed;
or 2·238 „ 1,000 „

Again referring to the summary we find that in 1883:—

134	deaths	resulted from	Explosions of Fire Damp.
469	„	„	Falls of roof and sides.
97	„	„	Shaft accidents.
246	„	„	Miscellaneous accidents, tubs, &c.
108	„	„	Accidents on the surface.
Total, 1,054			

as against 1,217, the average of the past 10 years.

In this paper it is only proposed to deal with the question of explosions, which as above mentioned, caused the death of 134 persons in 1883. Though this number compares favourably with 239, the average of the last 33 years, experience teaches us that we have no guarantee that this will not be exceeded in future years. For instance—

In 1859 there were only 95 deaths from explosions, while in the next year, 1860, there were 363 deaths from the same cause.

In 1864 there were 94 deaths,

While in 1866 there were 651 deaths from explosions alone.

In 1876 there were 95 deaths,

As against 586 deaths in 1878,

And 499 deaths in 1880.

The first consideration is the management. By the Coal Mines Regulation Act of 1872 it is enacted that none but men holding Government certificates of fitness shall be placed in charge of a colliery. These certificated managers are responsible for the safety, &c., of the pits under their charge, and in certain cases may be fined, suspended, or placed on their trial for manslaughter. This is a great responsibility for any man to undertake, and unless he is to be a mere figurehead to comply with the law, the manager

should either have entire control of the underground workings, or, if required to act under an agent, such agent should be a thoroughly qualified man, who has himself felt the responsibility of actual management, and who therefore would not be likely to place his subordinate in a false position. It is also important that the underlookers and firemen should be thoroughly competent men, and alive to their responsibilities.

From the very nature of explosions, sudden, unexpected, and far reaching, carrying off all those who might, if spared, have testified to the state of affairs at the time of the accident, subsequent inquiries into their origin, however carefully conducted, have afforded little or no definite information to guide us in the future. Of late years, however, careful experiments with so-called safety lamps and coal dust have revealed unsuspected sources of danger, and furnished a probable explanation of many of our most disastrous, and hitherto unaccountable, explosions.

Explosions causing great loss of life have occurred in mines where there was no evidence of the presence of large accumulations of gas, and the cause has been ascribed to sudden outbursts of gas. This may or may not have been the case, but the experiments with coal dust conducted by Mr. Galloway in South Wales, and more recently by Herr Margraf in Germany, show conclusively that a mixture of only five per cent. of fire-damp and air when ignited is sufficient, with the assistance of coal dust, to cause the most violent explosion. Fire damp is given off by all seams of coal, in many very freely, and the obvious course is to dilute or remove it as it issues by a current of fresh air. Powerful furnaces and fans have been erected, and immense volumes of air passed through the mines, but still explosions from time to time startle us out of our fancied security. Huge totals of air in the main returns, and fan drift are of

little use unless properly distributed in the workings, and with inferior lamps, such as the Davy, are a source of danger.

Given ample ventilating power, the next thing is to see that the intakes and returns are of sufficient area to pass the quantity of air required at a moderate velocity; and having done this, too much importance cannot be given to the question of subdividing the air current in the various districts of the mine, so as to arrive at a good system whereby the splits shall be proportioned to the work they have to do, and every opportunity given for the gas to follow its natural course and rise to the highest point. This arrangement of the splits is well worth all the care and thought that can be given to it, as a good system once established gives much better results and much less trouble in the long run than a mere haphazard method.

The method of ventilating "strait" places by sheet iron or canvas pipes is thoroughly bad in principle, and is fortunately very seldom used, for although a brisk current may be produced at the end of an 18-inch pipe, with an area of only 1·76 square feet, yet this current spread over a place, say 9 feet by 4 feet, or 36 square feet in area, is too sluggish to be of any use. Pipes are sometimes employed with advantage to air a short rise tunnel, when brattice would probably be blown down or damaged by flying stones after shots, or to clear some cavity in the roof when ordinary brattice could not be fixed. The usual method of airing "strait" places is by means of brattice cloth, which, if carefully put up, and nailed to wooden strips running next the roof, is very efficient up to a certain distance. When driving narrow work in a fiery mine ample space should be left behind the brattice to pass a brisk current of air, which, after sweeping the level and face, would return behind the cloth on the higher side. The one current should not be

expected to air too many places, and the cloths in each last opening should be scaled, to allow fresh air to mix with the return air from one place before it passes on to the next. The openings should not be too far from each other, and should be driven down brow when practicable. It is needless to say that the cloth should be well put up, and kept within 6 or 8 feet of the face. When the body of air on any level shows an appreciable cap on the lamp it is a certain indication that more air is wanted, or that it has done duty for sufficient places, and arrangements should be made at once either to increase the quantities, or else to pass the air over a crossing into the return, and start afresh with another split. If a "blower" is met with which shows a cap of any size on the lamp in spite of a good current of air, an opening may be driven at once downbrow, or, if only a short distance past the last opening, the place should be stopped and allowed to drain. These are not imaginary cases, but occur often in opening out new mines, and therefore the use of powder in such mines should be avoided. Air from pillar workings should never be used to ventilate narrow work.

In working pillars the air should always be discharged at the highest level, so that the goaf may empty itself, gases naturally rising to the highest point. If no gas can be found at this place, it is fair to assume that the goaf is pretty clear from gas. If, however, the air is worked downwards, and though the edges of the goaf may not show any gas when there is a good current of air, yet it is almost certain that the goaf behind is full of gas, as it cannot relieve itself. Less air, worked upbrow, will keep a district free from gas than a larger quantity worked the opposite way, and one feels more confidence that the goaf beyond reach of examination is clear, a most desirable result. Here, too, the cloths should be scaled as in narrow work, and the same split must not be expected to serve too many places. The

danger attending the first heavy fall of roof, especially in a newly opened mine, has each day forced itself more prominently on the writer's attention, and I believe that in some cases, when the explosion has been supposed to originate in an outburst, the gas has simply come from a fall of roof, which has been set down as a consequence of the explosion, instead of the precursor and origin of the disaster. More or less gas is given off from the roof in every such case of "first weight," and in one instance which has come under my notice, sufficient gas was given off to fill the goaf as far as it could be examined, 60 yards of the topmost or return level, and to show a cap for some distance down the back jigbrow for twelve hours in spite of a good air current. Fortunately this happened at 8 p.m., when nothing but the prop-drawing was going on. I myself have heard gas issue with the noise of a small steam jet when a slight fall was taking place in a newly-commenced "wall," and have been told of other similar instances.

With the knowledge of these facts, and having often noticed that the return air from the topmast wall of a district in which pillars are being worked, after showing no indication of gas for weeks, suddenly begins to show a greater or less "cap" on the lamp, at times revealing the presence of a large quantity of gas, the writer, after careful consideration of the subject, feels convinced that in many of our mines we may, and often do, have, when commencing long wall or pillar workings, unsuspected accumulations of gas in the roof or floor sufficient to cause an explosion. For the sake of clearness I will only speak of the roof, though the same remarks apply equally to the floor. Suppose we have, immediately over the coal, a tough metal roof, say 6 yards thick, and above that again a hard rock. When the pillars have been removed the metal, being tough, parts from the rock above, and sinks or bags in the middle to the

extent of one or two feet long before it will fall, thus forming a reservoir in which gas can accumulate unseen, possibly at a pressure proportionate to the quantity of gas existing in the roof, and the strength of the metal below. Suppose that the metal has sunk one foot from the rock in the middle of the newly-formed goaf, or, say, an average of 3 inches over the whole area, which we will assume to be 50 yards by 20 yards, we should then have over 2,000 cubic feet of gas ready to be discharged as soon as a fall of roof takes place and allows it to escape. This 2,000 feet, if at a pressure of more than one atmosphere, would expand accordingly when liberated, but even at the atmospheric pressure would be a very serious quantity of gas to deal with, however good the ventilation. I account for the discharge of gas previously referred to in this way, and think that accidents may have occurred under similar conditions in mines where any such accumulation of gas was unknown and unsuspected, and, the reservoir having emptied itself before the explorers could restore the ventilation sufficiently to examine the workings, no clue was afforded as to what had occurred at the fatal moment, all those who could have told us having perished. It is, therefore, advisable to keep the topmost level leading from the pillar workings for a return only, and under no circumstances to allow "drawing" or "jigging" to be carried on where such return air travels; for, should gas be given off, or forced out, from the goaf by a sudden fall, it must travel with the air, and meet the lamps of the workmen running against the current to escape into the fresh air. Boreholes to allow of the escape of gas from the floor have been put down, in some instances with good results.

In my opinion long wall is not, as regards immunity from explosion, superior to pillar and stall, provided that both systems are equally well carried out. Long wall has,

however, this very great advantage that powder is seldom required, and with a long face, having many breaks in the roof, caused by the successive "weights," the gas in the roof can vent itself gradually, and the larger volume of air coursed round the long wall face is not so easily fouled. The "first weight," however, requires as much attention as in pillar and stall, in fact more, for whatever gas is given off cannot be passed into the return, as in pillar and stall, but is carried by the air current past most of the men. When working to the rise, the above-mentioned "breaks" are often very troublesome to keep clear. They are necessarily close to the men at work, and a slight fall near one of these "breaks" in the day time at once converts a small quantity of gas in a narrow "break" into a goodly-sized accumulation, perhaps unnoticed for some time. If you try to force the air by means of cloths into such a break the ventilation of a good part of the workings may be seriously checked. The same result occurs in case of a fall across one of the stall faces. It is, therefore, well to scale the cloths in some of the gate-roads, both to freshen the air and provide, to some extent, for emergencies of this sort.

Experiments have proved the dangerous part played by coal dust in producing or aggravating explosions, but there seems to be no means yet known of avoiding it. True, we are advised to water our main roads (no little matter in a large colliery), but this, if done, would in many mines spoil the roads by causing the floor to lift, and, after all, only touches the fringe of the question. For what are we to do with the working faces, where every stroke of the pick makes dust, where every spadeful of small coal filled into the tub raises a cloud greater in proportion to the briskness of the ventilation, where gas is most likely to be found, where the most lamps are, and, worst of all, where powder is most used? The main roads can be kept fairly free from

dust by paving with bricks, or pieces of thin propwood placed across the road and under the rails, filling any accumulations of dust into tubs, to be sent out as required; but some practicable scheme for laying the dust in the workings is still urgently needed.

Neither gas nor dust can produce an explosion without some flame to cause their ignition. In dealing with gas great strides have been made of late years both in ventilating apparatus and discipline; but the real source of danger, namely, the possible means of firing the gas, if present, has not received anything like the same attention. The flame necessary to ignite the gas may be provided by candles, by an inferior type of lamp, by a good lamp sent out in bad condition or damaged in working, by wilful exposure of the lamp flame or use of matches, or most likely by a blown out shot. The use of *candles* seems an anomaly in coal mines, and no apparent advantage can compensate for the risk attending open lights. The lamp in almost universal use until quite recently was the Davy, and, unfortunately, thousands of them are still taken down our pits every day, in spite of the knowledge that, although very useful in the hands of firemen for the purposes of examination, the Davy lamp is absolutely unsafe in explosive currents of air and gas having a speed of 8 feet per second, a velocity very common now-a-days. With two other lamps before us, such as the Mueseler and the Marsaut, which give a much better light than the Davy, and which have satisfactorily withstood severe tests, there is no reason for clinging to a lamp which, however well it may have answered its purpose in bygone days, when there was no better lamp known, is totally unfit for use in modern well-ventilated collieries. The best lamp known, properly secured, and provided, cleaned, and maintained by the owners, is absolutely necessary for the safe working of our coal mines. Good

discipline and constant watchfulness on the part of all, both officials and workmen, should prevent any danger arising from defective lamps, or unlawful exposure of the lamp flame. Undoubtedly, so long as gunpowder is used for blasting in coal mines, will there be a great risk of mishap through a blown-out shot. We jealously protect the small flame of our lamps, and yet run the hourly risk of producing, with a blown-out shot in a dusty mine, a flame perhaps 40 or 50 yards long, beside a concussion sufficient to derange the ventilation of the district. When could we find conditions more favourable to an explosion than during working hours? the face of coal giving off gas with every stroke of the pick, the air loaded with dust and fouled with powder smoke, etc., the ventilation disturbed by the concussion of shot after shot, by the passing of tubs, and continual opening and closing of doors and cloths, the air slackened when the furnace, if any, is being cleaned out, and the shot-lighter always in a hurry to get to some other place where he is wanted. Under these ordinary conditions a blown-out shot, meeting the smallest quantity of gas, may cost the lives of all the men in the pit—a risk too great, one would think, to be tolerated even for a moment. I therefore fear that we must expect explosions as serious as any in past years, in spite of better lamps and discipline, until the firing of any shot, whether in the coal, or for blowing roof or floor in the main roads, is totally prohibited, unless all workmen are out of the mine, except the shot-lighters and furnace man, if any. There can be no question that this latter method affords much less risk of an explosion, apart from the fact of very few lives being at stake, instead of a whole pit set. The fan or furnace men redouble their watchfulness during the hours when shots are being fired, the ventilation is undisturbed, there is no dust, no hurry and bustle to prevent the shot-lighter making the most thorough examination of

the places and shot holes, no one to persuade him against his better judgment to fire a shot he would rather leave unfired, and the shots are fired in their proper order, commencing at the return end and working back to the fresh air.

The actual value of the barometer as a warning of danger from gas in coal mines seems an open question, useful as it undoubtedly is as a weather prophet. A fall of 1-10th of an inch in the column of mercury is equal roughly to 53 yards of a vertical column of fire damp, so that large quantities of gas would be given off from stagnant goaves before the fall of the barometer was appreciable; but artificial ventilation is capable of dealing with this gas as it is given off, and, if the air from the highest point of such goaves passes no one, but is discharged at once into the return, no danger need be apprehended from this cause. A reduction of atmospheric pressure, indicated by the barometer, may, however, hasten the falls of roof, and so liberate any gas accumulated in such cavities in the roof as have just been described, but such falls would occur in due time, whatever the state of the barometer. Mr. Corbett in his paper on "Observations taken at Seaham Colliery during the time the Maudlin seam was sealed up," states that he finds "That the barometer only recognises what may be termed general or clearly-defined great fluctuations, and even then very slowly," and that "Generally the barometer is not a true indicator to mark the giving off of gas, and it is well known that gas is frequently found in colliery workings before any fall of the barometer commences." As to narrow work, the experiments of Mr. Wood, in Durham, show that gas exists in solid coal at a pressure of 461 lbs. per square inch, and this in a mine which had been opened out 11 years. A fall of an inch of the barometer, reducing the external pressure about half a pound per square inch, would make little difference even

with a much less internal pressure than this, and Mr. Wood states, "That there is no connection between the variations of the barometrical column, and the temperature, with the quantities of gas evolved" from the solid coal.

In an interesting article on "Colliery Explosions and the Weather of 1884," the writer tells us that of the explosions which took place during the past year, fifteen occurred with a high or rising barometer, two when it was low or falling, and four appear to be connected with high temperature rather than with the slight changes of pressure at the time; which facts confirm my strong opinion that we must look for some other explanation of the liability to explosion at certain periods, and that a reliable apparatus to give warning has yet to be discovered. High temperature lessens the ventilation to a great extent, and possibly certain conditions of the atmosphere, such as saturation with moisture, &c., may lessen its power of diluting or removing gas. The same writer gives expression to a widely-spread belief "that miners, thinking bad weather and danger have passed away, feel no necessity to restrain the powerful passion for the soothing weed;" and he further says "there can be no doubt that many lamentable disasters have been the result of this kind of recklessness." I can only say that in my own experience I have never known of a collier smoking in the pit where forbidden, and have only read of one instance. I cannot find, during the same time, that any explosions in pits where lamps were used have been traced to such a cause. In the absence of proof, it is hardly fair to lay all the blame on those who have to pay with their lives the penalty of everyone's carlessness, whether workman or official, if there should be anything of the kind. Pipes and matches are occasionally found on searching the men's clothes, but this, though an offence for which they are justly punished, may happen through forgetfulness or other causes, without

any intention on the man's part of smoking or relighting his lamp in the pit.

In conclusion, the following are, in my opinion, the great points to be looked to for the prevention of explosions :—

1. Good management and discipline.

2. Ample ventilating power, large airways, and judicious distribution of the air in the workings.

3. The best possible lamps, which should be provided, cleaned, and maintained by the owners, and furnished with proper means of locking.

4. As little powder as possible to be used, and no shots to be fired on any account when any workmen are down besides the actual shot-lighters.

5. Careful attention to "first weights" and dust.

During the past year the number of deaths from explosions was only 65, as against 134 in 1883, and I earnestly hope that we may be able in future years to speak of the accident which occurred on December 18, 1884, as the last explosion on record; but, unfortunately, since this paper was prepared we are once more startled with a serious explosion and a loss of forty lives.

Mr. WOODWARD: The paper is a very comprehensive and interesting one, and covers a great deal of ground and gives much to think about.

The CHAIRMAN said he did not know whether it would be convenient to enter upon the discussion at once or wait until Mr. Burrows could give them the second part of his paper.

Mr. BURROWS said the subject being so comprehensive, he thought the better plan would be to take up this part and finish it, leaving the other to be dealt with later on.

Mr. G. PEACE said there was plenty of room for debate, and he was glad the subject had been brought before the Society. He agreed with many of the suggestions thrown out in the paper.

Dr. BLACK asked Mr. Burrows whether a complete method of laying dust could not be applied in collieries, as, for example, is done in the public streets, by watering-carts.

The CHAIRMAN: I suppose the general feeling to be that it will be better to discuss this paper at some future time, after it has been printed and is in the hands of the members. Many of the points brought before us are of great importance, and I have no doubt some little thought will be required before we express our opinion upon them. I quite agree with Mr. Burrows that the difficulty of watering the roads is one which has not been met. But the main roads are not the places where the danger from coal dust principally arises. Explosions do not generally originate there, but in the workings, and I do not think Dr. Black quite appreciates the various difficulties. I have seen the idea of sprinkling salt on the roads, etc., but all such suggestions are beset with difficulties. There is another matter which Mr. Burrows has dealt with pretty fully, namely the firing of shots. I fear the ruling he has laid down cannot be accepted for all mines; so very much depends upon the conditions, and the quantity of gas that is produced. In many collieries in this district, where the amount of gas given off is exceedingly small, such a rule, namely, that all the men should be out when the shots are fired, would be simply to waste the men's time and cause a great deal of unnecessary trouble.

Mr. BURNETT asked whether explosions were more frequent in dry or in wet mines? If they are less frequent in wet ones that would be a sufficient answer to the question of watering the road ways.

Mr. STIRRUP called attention to the Index to Vol. 10 of the Transactions of the Chesterfield and Derbyshire Institute of Civil Mining and Mechanical Engineers. The whole of that volume, he said, appeared to be devoted to researches into the causes of explosions and the best means of preventing them. Some very distinguished authorities upon the subject, both English and foreign, being cited.

Mr. BARRETT thought it a very good sign, when, in a body like this, gentlemen, having so much on their hands as Mr. Burrows has, gave the Society the benefit of their experience and knowledge on such practical subjects. Several of the points brought out in the paper were new to him, and when the time came for discussion, he probably would have some questions to ask with regard to them.

Mr. WOODWARD said that Mr. Burrows touched upon fifteen different points in the course of his paper—some of them of great importance; it is therefore difficult to enter upon a discussion at this stage.

Mr. TONGE said he cordially endorsed most of Mr. Burrows's conclusions. As to the relative advantages and disadvantages of long work and pillar and stall, he was very disposed to think that the long work possesses the greatest advantage. He hoped to have something further to say when the paper has been published in the transactions.

Mr. MARTIN said he was glad to find that Mr. Burrows is not disposed, as is so frequently done, to indiscriminately charge the collier with being the source of accidents in mines. He thought excessive importance was frequently attributed by the public to atmospheric variations (as indicated by the barometer) when considering the subject of Colliery Explosions. Adequate ventilation appeared to him more closely connected with the question, together with the movements of the strata (roof, flooring, etc.,) when it is

remembered that gas is known to exist pent up in them at 700lbs. on the square inch. The accumulations in goaves are no doubt affected, but his argument is that if such become a source of danger by such changes of the atmosphere, the ventilation is inadequate, in as much as he considered that the ventilation should have such a margin above ordinary requirements as will remove completely and safely all gas which may exude at the edges of such goaves, whatever may be the changes of the barometer. Colliery Managers would be unworthy of their positions if their system of inspection or ventilation required improvement upon each warning of forthcoming barometric variation, and indeed he would feel that he courted a rebuff, which he would surely get, if he told them that such was the case. The manager needing such warning was he thought the very one unlikely to avail himself of it. He was glad to notice that Mr. Burrows does not favour the use of naked lights, a practice which, in certain districts, is still clung to very tenaciously. It is alleged that a candle is more convenient, and gives a better light than a safety lamp, and no doubt when compared with the Davy the light is incomparably superior; there are now however improved lamps, from which two-thirds of the light of a candle can be obtained, as compared with one-eighth from the Davy, therefore the force of the argument is no longer so strong as formerly. The use of powder in mines has been a good deal debated and condemned, entirely due to its use where not safe. The laying out of a mine at first is, perhaps, one of the most important points referred to in the paper, and one too often not sufficiently considered from an economic point of view, beyond the immediate circumstances.

The CHAIRMAN: The newspaper warnings seem to me often misleading in the matter of temperature. They assume a greater heat in a mine in summer than in winter. Now I

have for many years had the temperature taken at the top of the pit and also at the bottom, and the register shows that at the far end of the workings in our old pit the temperature does not vary between the hottest day in summer and the coldest day in winter more than one degree and a half. Therefore the heat cannot have any very great effect in expanding the gases below.

Mr. WARBURTON said he had had a thermometer suspended at the bottom of an up-cast shaft, and it always registered the same. He wished to ask Mr. Burrows whether he finds in the long wall proper many falls of roof to occur. He did not himself find many; with him the roof gradually sinks and does not break off wherever the faces are kept going forward constantly and regularly. He had been accustomed to use the watering tub even up steep brows and on levels; it serves two purposes—it lays the dust nicely, and prevents the rails being so readily misplaced. His experience is that the watering of roads in a mine, wherever practicable, is advantageous in more respects than one.

Dr. BLACK said that as the winds and cyclones do not penetrate into the recesses of a mine, he could not expect the barometer to be affected in the same way in a mine as it would be at the pit's mouth.

The CHAIRMAN said that the action of the barometer below and above ground corresponded.

Mr. BURROWS said he would answer only two questions, leaving the rest to stand over. As to watering—he could not give the exact figures, but there is in one case, he thought, about 1,400 yards of wall face that would have to be watered if the watering was to be efficacious. The coal is very dry and dusty. Dust is raised by the filling of the tubs and in other ways; there would, therefore, be a very considerable space to cover; and there would probably

be more water knocking about the pit than coal, if it were attempted to water such places. The Chairman's remarks about powder, Mr. Tonge's about long-wall, and also those of the last speaker will be noticed at a future meeting. He could not reply authoritatively to Mr. Burnett's question. All the explosions that he could call to mind have been in very dry mines; but he should not like to give it out as a general rule.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XVIII. SESSION 1884-5.

EXCURSION TO SHEFFIELD AND ALDWARKE.

The Honorary Secretaries having obtained permission from the directors of the Atlas Iron Works, Sheffield, for a party of the members and their friends to visit the extensive iron works and collieries belonging to Messrs. John Brown & Co., Limited, a large number of the members availed themselves of the opportunity. The visit was fixed for Thursday, the 26th of March, on which day a party of about fifty-four assembled at the London Road Station, and entered a special train which had been provided for the purpose by the Manchester, Sheffield, and Lincolnshire Railway Company. Leaving punctually at the time fixed, 9-20 a.m., Sheffield was reached, without stoppage, at 10-30. The members at once proceeded to the Atlas Works, where, on arrival, they were received by Mr. J. D. Ellis, the managing director.

Entering the works at once, the party was soon busily engaged in witnessing the process of armour-plate making (an industry for which these works are famous), and the no less interesting apparatus by means of which these ponderous plates of metal are moved by powerful cranes and machines from place to place, and carried to the rolling mills, where

they are firmly welded and compressed, masses of 30 tons weight being thus manipulated with marvellous ease and dexterity.

Mr. Ellis had kindly arranged for the party to see the mode of procedure in making one of his patent compound (steel and iron) armour plates. This operation, which was witnessed with evident interest, consisted in the uniting with a weld of molten steel a thick armour plate of 12 to 14 inches of iron with one of 6 or 7 inches of steel, weighing together about 30 tons.

The united plates (with the cavity about to be filled) were seen to issue from the glowing furnace, where they had been raised to the proper heat, then the mass was seized by the great 60-ton crane and deposited in a trench prepared for the purpose. Here the space separating the steel and iron plates was filled with molten steel from a huge cauldron, which had received its supply from the Bessemer converter in another part of the works. After the filling is completed, the compound plate is conveyed to a powerful hydraulic press, where it is subjected to a pressure of about 4,000 tons, in order to consolidate and more intimately unite the fibre of the metal. Afterwards it is replaced in the furnace for another 24 hours before being finally rolled and completed. The Bessemer process of steel manufacture, the making of solid wheel tyres, and the inspection of the various shops containing gigantic planing machines, &c., occupied the remainder of the time which could be devoted to the works.

The members had the advantage not only of Mr. Ellis's presence, but also that of several departmental officials—Messrs. Richards, Pochin, Buchanan, Townsend, and others—who accompanied the party in their progress through the works, giving explanations when and wherever required.

The members, before leaving the works, manifested the

pleasure and interest which the visit had given them, and expressed their thanks to Mr. Ellis and his *aides*, who had enabled them to see, in the short space of two hours, operations which could only be shown in two or three works in the world.

The members, retracing their steps to the station, resumed their places in the special train, and proceeded to Aldwarke Main Colliery, belonging to the same firm, where they were received by Mr. C. E. Rhodes, general manager of the colliery, and his assistant, Mr. Hedley, who, with their several stewards, enabled the works to be seen to great advantage.

Some viewed the surface arrangements, while other parties descended the pits to see the haulage arrangements, and others the lime process for breaking down coal. The latter was tried in a long wall face, a portion, 7 yards in length, having been holed 4½ft. deep, and the holes prepared for the insertion of the cartridges. The coal was in this way broken down, the time required being about one hour. This process, it is maintained, is an efficient substitute for explosives under certain circumstances, but it cannot be said to be either as cheap or quick.

The whole party afterwards reassembled in the waggon shop, where a most complete arrangement has been erected for making experiments with safety lamps, and Mr. C. E. Rhodes made a large number of experiments, to show the relative safety of various lamps.

Many of those present being connected with collieries, as owners, agents, or managers, were, of course, much interested in these trials, a summary of which will be found at page 186.

At the conclusion of the experiments the party adjourned to dinner, Mr. W. S. Barrett, Vice-President (in the absence of the President), occupying the chair.

The Chairman, after dinner, said they had seen at

Sheffield that day something that probably many of them had never seen before, and they had all been highly gratified by the inspection which they had been permitted to make of the works of Messrs. John Brown and Co., and the interesting processes in connection with the manufacture of armour-plates they had seen in operation. With regard to the works at the collieries, he was sure they had all seen something that would tend to their improvement. For the kindness which had been shown to them during their visit that day he had great pleasure in proposing a most hearty vote of thanks to Messrs. John Brown and Co., coupled with the name of Mr. C. E. Rhodes, to whom they were indebted for the valuable series of lamp experiments they had been able to witness during the afternoon.

The vote of thanks having been most heartily agreed to,

Mr. Rhodes, in responding, said he was extremely obliged for the vote of thanks they had accorded to him for the privilege he had had in showing them round the collieries, and the lamp experiments he had been able to lay before them. As to the lamp experiments, the idea had originated with Mr. Chambers and two or three other gentlemen connected with the mining industry, on finding that the Davy and Stephenson lamps were unsatisfactory. Their object had been to ascertain whether there was a really safe lamp, and to find out whether they had been working in the dark for years. There had been in the papers at various times a considerable amount of correspondence upon this subject, and the point upon which the greatest amount of discussion had taken place was as to who was entitled to the credit of the shield or bonnet which had been applied to many of the lamps. The application of this shield had no doubt been a great stride in arriving at what was a safety lamp. When he began the experiments the only lamp fitted with a shield forwarded to him for trial was sent by

Mr. Smethurst, but after a considerable time they had it on other lamps, and when they got up to velocities of 30ft. per second they had dozens of lamps sent up with the shield, those who forwarded them in many cases claiming that long ago they were fully acquainted with the shield, but from some cause or other it had not been introduced. As, however, Mr. Smethurst was the first man who really pointed out the utility of the shield, he thought he was entitled to the credit of it. It had, however, been proved that the loose shield was a mistake; they then commenced having a shield fixed at the bottom, and he did not know whether Mr. Marsaut or Mr. Smethurst was entitled to the credit of this particular shield, but certainly one of them was. What they had gone for had been simply subjecting the lamps to one current, and that current to be of the highest explosive point. Their reason in subjecting lamps to these high velocities was not that it was probable lamps in ordinary work would have to encounter such currents, but because they thought a lamp should be made to stand a strain eight or ten times in excess of the ordinary current, so that there might be an ample margin of safety for any possible emergencies. They were now going to test lamps up to 100ft. per second of two or three minutes' duration, and they hoped that before long their experiments might induce gentlemen to bring out some lamp better than anything they had got at present. He firmly believed that in the future the risk of explosions would be reduced and minimised by improvements in safety lamps, and when miners and managers began to have a safety lamp they could understand.

Mr. P. G. Pochin, chemist to Messrs. John Brown and Co., and Mr. Buchanan responded on behalf of the Sheffield department.

The toast of H.M.'s Inspectors of Mines, was responded to

by Mr. HALL; that of the Hon. Secs., by Messrs. J. S. MARTIN and M. STIRRUP; and the toast of the presiding Vice-President being warmly acknowledged, brought to a close a pleasant and instructive visit. The members then moved off to the special train which was awaiting them at Aldwarke Station for return to Manchester.

At the ORDINARY MONTHLY MEETING of the Members of the Society, held on Tuesday, the 14th day of April, 1885, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

HENRY HALL, Esq., H.M.'s Inspector of Mines, Vice-President, in the Chair.

Mr. C. E. HINDLEY, Bank Colliery, Little Hulton, was unanimously elected an ordinary member of the Society.

The following are the recent additions to the Library:—

Chesterfield and Derbyshire Institute of Engineers: Transactions—Part 4, Vol. 10; Part 3, Vol. 13.—*From the Institute.*

Hertfordshire Natural History Society and Field Club: Transactions—Parts 3 and 4, Vol. 3.—*From the Society.*

Leicester Literary and Philosophical Society: Inaugural Address, Session 1884-5, by Dr. Shaw.—*From the Society.*

Liverpool Free Library and Museum: 32nd Annnal Report, 1885.

London: Geological Society, Quarterly Journal, No. 161, Vol. 41.—*From the Society.*

Ditto, Geologists' Association, Proceedings, No. 8, Vol. 8; Index to Vol. 8; No. 1, Vol. 9.—*From the Association.*

Ditto, Royal Society: Proceedings, No. 235, Vol. 38.—*From the Society.*

Ditto, Society for Psychical Research: Proceedings, Part 7, 1884.—*From the Society.*

Ditto, Institution of Mechanical Engineers: Proceedings, No. 1, 1885. *From the Institution.*

Ditto, Geological Magazine, April, 1885.—*Purchased.*

Manchester: Report of Proceedings of Manchester Association of Employers, Foremen, and Draughtsmen, and 3 Pamphlets.—*From the Association.*

Midland Institute of Engineers: Transactions, Part 75, Vol. 10.—*From the Institute.*

Mining Institute of Scotland: Transactions, Part 8, Vol. 6.—*From the Institute.*

North of England Institute of Engineers: Transactions, Parts 1 and 2, Vol. 34.—*From the Institute.*

Ditto, Strata of Northumberland and Durham, as proved by Borings and Sinkings. F. K. 1885.—*From the Institute.*

South Wales Institute of Engineers: Proceedings, No. 2, Vol. 14.—*From the Institute.*

Yorkshire Geological and Polytechnic Society: Proceedings, Part 3, Vol. 8, 1884.—*From the Society.*

U. S. A. Columbus: Report of the Geological Survey of Ohio. Vol. 5. Economic Geology. *From Edward Orton, State Geologist.*

Indianopolis: Department of Geology and Natural History. 14th Annual Report, by John Collett, 1884.—*From the Department.*

Philadelphia: Journal of the Franklin Institute, Nos. 709-712, Vol. 119. *From the Institute.*

New York: American Museum of Natural History, Annual Report of Trustees, 1884-5.

Toronto: Canadian Institute, Proceedings, No. 1, Vol. 3, Third Series. *From the Institute.*

Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 3, Band 36.—*From the Society.*

Lausanne: Bulletin de la Société Vaudoise, No. 91, Vol. 20.—*From the Society.*

Paris: Revue de la Legislation des Mines, Jan., Feb., Mar., 1885.—*Purchased.*

Pisa: Atti della Societa Toscana di Scienzi Naturali, Memorie Fasc. 3, Vol. 4.—*From the Society.*

Roma: Atti della Reale Accademia dei Lincei, Fasc. 1-4, Vol. 1, 1884-5. *From the Academy.*

St. Petersbourg: Académie Impériale des Sciences, Bulletin No. 4, Tome 29; Mémoires No. 13, Tome 32.—*From the Academy.*

DISCUSSION ON MR. J. S. BURROW'S PAPER ON ACCIDENTS IN MINES.

Vide Page 150, Part VII.

PART I.—EXPLOSIONS.

Mr. G. H. PEACE said he had read the paper very carefully through, and considered it a very interesting and valuable one. In almost all matters he agreed with Mr. Burrows, and there seemed, to him, but little to discuss. On some

points, it was true, there might be differences of opinion. He agreed with Mr. Burrows (with regard to the liability to explosions) that it was generally the first weight which gave the greatest trouble; and there was more danger then than at any other time, whatever might be the state of the barometer. He further agreed with Mr. Burrows as to the great importance of so laying out the works, in the first instance, that ascensional ventilation was provided. As regarded the relative merits of pillar and long wall he also agreed with Mr. Burrows; he did not think there was much to choose between the two systems so far as the risk of explosion was concerned. If both were worked with the same skill, and the same care, then, in his judgment, one was just as safe as the other. The differences in the circumstances of the mine were, he thought, of much more importance in considering the mode of working to be adopted. There was one other point, namely, with regard to lamps. It was very desirable, as Mr. Burrows said, that these should be owned by, and under the care of, careful and experienced persons appointed by the colliery proprietors. His firm had been for some time gradually introducing that system.

Mr. Tonge said: I stated at the last meeting that Mr. Burrows and I did not quite see together as to the relative merits of the two systems—pillar and long wall. I therefore feel myself compelled to say a word or two upon the same point to-day, though I cannot quite agree with Mr. Burrows. On page 162, he has summarised his paper—first, "Good management and discipline." In that I quite agree with him. But it struck me, in addition to what Mr. Burrows said, that if colliery proprietors would institute classes for the instruction of working miners, firemen, and underlookers, and personally visit those classes from time to time, very great good would result. I know that classes are

sometimes started, and after a while fall through; but that, I think, is largely due to the lack of personal interest in them on the part of employers and other influential persons in the district. Referring to changes in the barometer, I quite agree with Mr. Burrows's observation (p. 160): "A fall of one-tenth of an inch in the column of mercury, is equal roughly to 53 yards of a vertical column of firedamp, so that large quantities of gas would be given off from stagnant goaves before the fall of the barometer was appreciable." I suppose Mr. Burrows means that one-tenth of an inch in a column of mercury is equal in weight to a column of fire-damp of 53 yards. That, of course, is plain; but I do not suppose Mr. Burrows means us to understand that if there is a body of fire-damp, 53 yards in vertical height, and the barometer falls one-tenth of an inch, 53 yards of fire-damp would be liberated. I shall be glad to hear further from him on that point. My opinion has been that so far as the gas which lies in goaves is concerned, it rises and falls with the barometer. Of course the expansion and compression of gases—that is, their increase or decrease in bulk—is governed by, and in inverse ratio to, the pressure; so that, if one-thirtieth of the pressure were taken off, the volume would be increased by one-thirtieth, and, the place being full, so much would pass away. As regards the relative merits of long wall and pillar and stall in connection with explosions, the only respect, as far as I am aware, in which long wall can be said to be more dangerous than the pillar and stall system is, that the men are constantly working on the margin of the place, which may or may not be occupied by gas. That is a point of danger; but inasmuch as the long wall enables us to work to a great extent without powder, and as powder is one of the principal causes of explosions—a statement, I think, which will hardly be controverted—the prime danger is by the adoption of the long

wall system removed. The long wall system has also two other great advantages—it lessens the friction of the air in its passage through the mine, and a colliery may be far better managed, and watched, where the colliers are in one line of face. On the whole, therefore, I am more in favour of the long wall system than the other.

Mr. STIRRUP called attention to a paragraph which had recently appeared in an English scientific journal, taken from *La Houille*, in which M. de J. Lebrun, in a paper "On Explosions of Fire-damp and Falls of the Barometer," says: "Several English engineers and men of science have sought to establish a coincidence between great barometric depressions and explosions of fire-damp. An inspection of the tables published by the French Commission on fire-damp does not appear to prove this. There are as many explosions at moments when the barometer does not vary and when it rises, as at those when it falls." With regard to the question of the best safety lamps, Mr. Stirrup inquired whether it was not a fact that the Belgian authorities made the Muesler type of lamp compulsory, to the exclusion of all others.

Mr. HOLLINGWORTH: I can agree with almost all that Mr. Burrows has advanced with regard to the barometer. I do not believe that any well-regulated place shows much variation. If Mr. Burrows's statement is correct about one-tenth of an inch of the mercury being equal to 53 yards of fire-damp—that is, in weight—I make it out that fire-damp is about eighteen hundred times more sensitive than the barometer; therefore a change must be very much more apparent with gas in a goaf than with the mercury in a barometer. As to the newspaper warnings, they appear to say something like this: "The barometer is going up," or, "The barometer is going down—take care;" and then, if anything happens within three or four days of that

warning, they say, "We told you so." As to the relative advantages of long wall and strait work with respect to explosions, I should not like to say that either one or the other is better. I think a well-managed place, working strait work, is just as likely to be safe as the other. Of course, in strait work you are sometimes liable to outbursts, which you are not liable to in long wall; but in the latter you are more liable to weights, as the face is moving. Looking at the advantages presented by the two systems, it is a case of balancing one against the other. I do not think either is to be considered the best as regards liability to explosion under every circumstance.

Mr. TONGE observed that gas might exist in goaves which could not be got at. They had the barometer at home, and could observe it at all times. The relative weights, however, of the gas and of the mercury was not the thing they had to look to, but the pressure under which the gas existed in the mine, because if the barometer fell an inch, and there were, say, 30,000 cubic feet of gas in a mine which could not be seen with the lamp, 1,000 feet of that gas would be given off. The use of the barometer would be that, whereas you might not know there was any gas existing, the mercury would show the depression, and indicate that watchfulness was necessary.

The CHAIRMAN (Mr. Hall) said: I think Mr. Burrows is to be congratulated on having given us a paper dealing with the subject of explosions, which is, to my mind, a very valuable contribution. It is not a very long paper, but it is very much to the point, and very practical. Mr. Burrows is evidently a man who has opinions, who has the courage of his opinions, and can express them very clearly. This, I think, is especially evident in the remarks he has made about shot-lighting. He tells us that no shots ought to be fired unless the whole of the men are out of the mine. I take it

he does not mean that to apply absolutely to every mine, but only to those in which gas is found. If a mine gives off no gas, it would be unnecessary to take precautions against gas in that mine. I have for a long time had the same view, that shots in fiery mines ought not to be fired unless the men are out, and I am very glad to be encouraged and supported in that view by a man who is engaged in the actual management of extensive collieries in which, I presume, it is put in force. Mr. Burrows makes a remark, in the first part of his paper, about the responsibility of managers, and says he considers that the manager should have the entire control of the colliery. Well, I think that is most important. For my part I have no respect for a manager who allows himself to be made the cat's-paw of his employers; and I have no respect for those employers who would wish to put him in that position. At the same time a manager should not, simply because a suggestion comes from his employer, refuse to give it consideration. If he uses a little discretion, he may please his employer and get his own way very much at the same time. I am glad to see that the author of the paper condemns ventilating by pipes. It has always seemed to me that where people use pipes in ordinary working it is when the air is so weak that they cannot lift it to the face by means of brattice, and one can best describe it by saying that it is simply helping a lame dog over a style. Mr. Burrows mentioned the subject of watering mines, but did not lay much stress upon it. Well, I hardly agree with him, for I believe that, in the future, very much more attention will be paid to the watering of mines; and the excuse people constantly make that to put water on the roadways causes the floor to lift is really groundless. If water is poured on by simply pulling a plug out of the bottom of a tub, the chances are that it will make the floor lift; but if it is put on as one would put it on

a street—a little over the whole surface—I think the dust will absorb it, and little harm will be done to the roads. Bearing in mind the fact which has lately been discovered, that dust is such a dangerous element, I do not see how we are to meet the danger from dust except by watering. It seems the natural way to meet it, and it is, I believe, the way in which it will have to be met. Mr. Burrows mentioned two or three means by which gas may be lighted: he said it may be lighted either by matches, candles, or a blown-out shot. Now recently some particulars of shot-lighting have been brought under my notice, and it comes to this, so far as I can understand them, that it does not require a shot to blow out to cause an immense amount of flame in the working place. Shot-lighters tell me that it very often occurs that even when a shot does its work perfectly, there is immediately following the shot a large sheet of flame on the face of the coal. I do not know how this is caused. Probably a large amount of coal breaks off, and gas is liberated, and ignited. I am told that it has happened frequently in different miners' experience, so we must not confine the means of lighting gas to the three things Mr. Burrows has mentioned. I believe ordinary shots may and will light gas. With reference to the barometer, I think there is no doubt that a fall of the mercury does affect the gas in pits. Any gas that is locked up, so to speak, in a *cul de sac* must expand if the pressure is taken off. Mr. Burrows, when he mentions 54 yards of gas, is, I presume, dealing with a column the height of the atmosphere, but the accumulations of gas met with in pits may be only 10, 20, or 30 feet high, or 10 to 30 feet wide, and it would only expand in proportion to its width or height. Perhaps a fall of half an inch in the barometer might cause it to expand about one-fifteenth of its bulk. Well, it would do no harm if it did not expand into an air-way, where the air passing was

inadequate to render it harmless; but if the expansion caused it to come out into an air-way where the air passed to working places, it would be a source of danger. All collieries ought to be so ventilated that any fall, no matter how great, in the barometer would not cause danger. If a man ventilated his colliery in such a manner that even every severe fall of the barometer was attended with danger, he would be like a man who built a house which would be blown down by the first storm. As to the newspaper warnings, I do not think they should be condemned quite, because, although perhaps the danger is past as soon as the barometer begins to fall, yet the newspapers tell us that, at such and such a time, two or three days hence, there will be a heavy fall of the barometer. Even assuming that the gas does begin to move long before, we can perhaps make some preparations, so that there may really be some utility in the warnings. I am very glad Mr. Burrows has told us about the dangers of dust and the dangers of air partially charged with gas. I think that is now the most important matter before the mining world—the discovery that air only partially charged with gas, along with dust, or perhaps dust itself, is dangerous, and may cause an explosion. I believe there will be the greatest possible difficulty in getting such men as firemen, who have been accustomed to look upon gas which would not explode in the lamp as not dangerous, to appreciate this danger. We can hardly imagine a fireman going and charging a shot, and lighting it, when he knew that there was a cap on the air, if he believed that that cap would actually cause danger. We know that they do light shots under such circumstances, therefore it proves that, up to the present time, they have not appreciated that danger. Mr. Burrows, in his concluding remarks, I was glad to see, put good ventilation before the question of lamps. Lately we seem to have

run a danger of thinking too much about lamps and too little about ventilation. There was a question asked—I do not know that it is my business to answer it—as to whether there were more explosions in dry than in wet mines. So far as I know, I should say there are a great many more explosions in dry mines; but we must remember that wet mines are generally mines near the surface, where there is less danger from gas than is the case with deeper mines, and perhaps that accounts for it. The discussion upon this subject, as far as it has gone, has been most interesting. The paper is a very good one, but we must not merely talk about it here; we must take it home and try and apply it.

Mr. Burrows, in replying, said he was somewhat disappointed at seeing so few mining members present. There were some, he knew, who differed from him on various points, and whose opinions and arguments he should have been glad to have heard. Some strongly advocated the use of powder in mines, in season and out of season. Referring to the remarks of Mr Tonge on the subject of the barometer and the effect of changes in the pressure upon fire-damp, he (Mr. Burrows) said he used the words "vertical column," in his paper, in speaking of fire-damp in mines: that was to draw attention to the extreme sensitiveness of fire-damp as compared with mercury. Mr Tonge had not said so much about long wall as he expected he would. Perhaps, having read the paper, he thought better of it. He (Mr. Burrows) was of opinion that if they were equally well managed, so far as freedom from gas, and consequently from explosions, were concerned, there was little to choose between long wall and pillar and stall. At the same time some of the largest outbursts ever known—that of the Oaks, for instance—have taken place in long wall; and from the nature of things, in a large face, nearly straight, if there is any gas 20 or 30

yards below, which is under any great pressure, there is every chance for it to lift the floor, and the efforts made to keep it up to the face takes it past the men. On the other hand, in pillar and stall, there might be a serious outburst; but if the workings were conducted on the plan suggested—the top level left empty—it might get away and never pass a soul. He recognised the kindness of spirit and the interest taken by the writers of the colliery warnings, which were published from time to time, and in his paper he carefully avoided saying anything against them. He was pleased to see such an evidence of interest in colliery matters by outsiders. He always read the warnings whenever he saw them, and asked those in the workings to note any change that might take place. But it seemed to him, notwithstanding all their scientific appliances, that what was most needed was competent men underground, who knew their business, and would attend to it. The Chairman had referred to the use of powder, and he asked whether the rule he (Mr. Burrows) suggested as to shot-firing should be made applicable to mines in which there was no gas? Well, he might be rather sceptical, but he had never yet seen a mine, nor heard of one, where there had been no gas. It was not very long since there was an explosion—he believed in Staffordshire—in which three or four men were killed; yet according to the evidence given at the inquest, which there was no reason to doubt, gas had not been observed in that mine for years. It showed itself on that particular morning in sufficient quantity to fire at a shot; therefore, it seemed to him if they were to go in for absolute safety they must go in for absolute precautions also. Under the present regulations the use of powder, except at night, was prohibited in a mine for three months after any discovery of gas. Well, if such a restriction could be applied for three months at a time, why not altogether? There was a temptation under the

present system, he would not say not to report, but not to see gas in a mine. As to watering, the difficulty was in laying the dust in working places as well as in the road ways. He did not undervalue the application of water, and should be glad to discover some effective system by which all parts of the mine could be reached.

THE SAFETY LAMP EXPERIMENTS AT ALDWARKE.

A discussion took place upon the safety lamp experiments conducted at the Aldwarke Colliery on the 26th March, of which the following is a summary:—

Lamp.	Velocity of current Per second.	Result.
1.—Davy	5 ft.	Went out after giving evidence that it reached very near explosive point.
2.—Davy	6 ft.	Fired surrounding gas.
3.—Clanny	6 and 7 ft.	Went out at 6ft., and fired at 7 ft.
4.—Stephenson	10 and 12 ft.	Went out at 10 ft., and fired at 12 ft.
5.—Williamson	12 and 14 ft.	Went out at 12 ft., and fired at 14 ft.
6.—Ordinary Mueseler	14 and 17 ft.	Went out at 14 ft., and fired at 17 ft.
7.—Mueseler with Smethurst or Marsaut bonnet....	14 and 17 ft.	Went out at 17 ft.
8.—Do. do., made by Messrs. Johnson, Clapham, & Morris		
9.—Marsaut with two gauzes	30 ft.	Fired gas after 1 min.
10.—Ashworth's lamp	30 ft.	Fired gas.
11.—Mueseler with shield	30 ft.	Went out.
12.—Routledge and Johnson ..	30 ft.	Gas burned until end of experiment.
13.—Tin Can Davy	30 ft.	Fired gas.
14.—Wm. Purdy's Lamp	40 ft.	Fired in 15 seconds.
15.—Routledge and Johnson ..	40 ft.	Fired in 40 seconds.
16.—Mueseler with shield	40 ft.	Burned slightly at bottom of chimney during whole of experiment.*

* This (slight) burning very often occurs, but it is so slight that we are informed that even when gunpowder is placed upon the horizontal gauze it will not affect it.

Mr. MARTIN said he was sure the Society must feel very much indebted to Mr. Rhodes for the trouble he took in showing these experiments to the members. The notes, giving the results of the experiments, were published on Mr. Rhodes's authority, and that gentleman, in a letter he had received from him, reiterated his opinion that the Mueseler was decidedly the safest of the lamps in use. The Marsaut, which is self-extinguishing in an explosive current of 22 feet per second, but explodes in one of 30 feet, is not, he thinks, so safe as the Mueseler. The latter goes out. The fact that it also goes out when turned on its side for a minute, or less, is, Mr. Rhodes thinks, in its favour: he adds—"When the men get into the way of using them they like them. He has 1,500 in use, and never has a complaint." Mr. Rhodes further said that the experiments were not so complete as if they had been made for the purpose of testing which lamp was the safest, but they showed comparative results, and that was really the object of having the excursion to Aldwarke—that many colliery managers in this district who had not had an opportunity of seeing demonstrated the comparative safety of the different lamps in use might be able to do so.

Mr. BURROWS said he had heard many colliery owners say that their men would not use the Mueseler lamp.

Mr. MARTIN: The difficulty with that lamp is in getting accustomed to carry it. I have myself started with a Mueseler, and have got without light in a very short time; but, with practice, it is carried with facility.

The CHAIRMAN: How do you find it for testing gas?

Mr. MARTIN: I cannot speak from much experience on that point. Mr. Sawyer, in the Transactions of the North Staffordshire Institute, maintains that he can detect a smaller quantity of gas with the Mueseler lamp than with the Davy:

the downward draught, he says, brings the gas down to the flame in the lamp, and enables small quantities to be seen.

Mr. BURROWS, in reply to a question by the Chairman, said the Davy lamp was the last in the world that he should take to search for gas. He found the Clanny lamp far more suited for the purpose.

The CHAIRMAN: You find it necessary to take some other kind of lamp than the Mueseler?

Mr. BURROWS: Our officials have two lamps—a small Clanny and a small Davy, The former, for the purpose of testing gas, I consider the best.

Mr MARTIN: The Chairman's question, as I understand it, is this—Can you discern a cap on the lamp with a Mueseler easier or otherwise than with the Davy?

Mr. BURROWS: I should say not so well, from what I have seen of them. I prefer a Davy to a Mueseler in examining for small quantities of gas. There is another matter: If you are not very careful with the Mueseler—if you pull the wick up, especially after it has been burning for two or three hours, you have a chance of finding yourself in the dark. If it is a good lamp, and one newly sent out, it may be right enough.

Mr. MARTIN: But for examining your return (not looking for gas in holes) to see whether the air is charged or not?

Mr. BURROWS: We always use a small Clanny for that purpose. I will undertake to find gas better with a small Clanny than with any other kind of lamp except a small spirit lamp, and that will show a cap exaggerated in size.

The CHAIRMAN said that he was amused at meeting, at

the Aldwarke Colliery, where the experiments were conducted, an old gentleman from Lancashire who had great faith in the Davy lamp. He had, he said, come there to see the Davy lamp explode; he had carried it many hundred yards in gas, and it never exploded. The chances were that that gentleman's belief in the safety of the Davy lamp was drummed out of him. Hence the value of the experiments.

ON COAL AND COAL PLANTS.

By Mark Stirrup, F.G.S.

Notwithstanding that recently, at our meeting at Owens College, we had the opportunity of hearing discourses on the Carboniferous Flora from Professor Dawkins and Dr. Williamson, I venture to take up the same almost inexhaustible subject, touching upon a few points which were not discussed on that occasion by the learned Professors.

Firstly, I would say a few words on the geographical distribution of our coalfields and the probable conditions, terrestrial and meteoric, under which they were formed. Although we must not hope to find coal under every latitude, yet explorations of various kinds have in recent years made us acquainted with the wide dispersal over the globe of deposits of coal belonging to that period of the earth's history known to geologists as the carboniferous period.

We have, as you know quite well, *brown coals* and *lignites* belonging to later geologic ages, but they are poor and insignificant in comparison with the coal deposits of the older formation.

When we compare the fossil plants of the carboniferous age from different English coalfields, and these again with

eminent French palæo-botanist, who has long and closely studied the fossil plants of his own immediate district—the coal basin of St. Etienne and the Loire—and has compared them with other European and American types.

The result of his labours has been the publication of a work, in which he asserts the possibility of determining the relative ages of the different beds of coal of any isolated basins by the examination of the paramount or prevailing species.

The importance which he attaches to this numerical preponderance of any group of plants is shown by the use he makes of it in his classification.

M. Grand'Eury has divided the Carboniferous Flora (with which he includes the Permian) conformable to his recognised order of development—into five *phases*—and these again are divided into zones marked by the advent of certain species and their numerical preponderance in any zone.

He classes, by their flora, the English coalfields in one great coal band, stretching eastwards from our shores, and including those of Flanders, Belgium, and Westphalia.

To the south of this line the isolated coal basins, such as those of Central and Southern France, belong to a phase of vegetation posterior to that exemplified by the English coalfields.

In the classification put forth by M. Grand'Eury, the Lower Coal Measures of Scotland are placed in the first or earliest *phase*, and the Lower and Middle Coal Measures of England in the middle zone of the second *phase*.

The coal beds of St. Etienne rank later in time, and are remarkable by the paucity of Lepidodendra and Sigillaria, and the relative abundance of Cordaïtes, tall growing trees (60 to 100 or 120 feet in height), allied to the conifers, whose *débris* are said to be the principal components of some of the thickest beds of this coal field.

Leaving this portion of the subject, I would ask your

attention for a few moments to the consideration of another point, and that is, the nature of the plants which go to form coal.

We have seen, from the examination of various coal beds, that the vegetable remains of which they are composed belong to different kinds of plants.

The question then arises, Has this difference anything to do with the various qualities of coal?

It has been said that certain coals found suitable for the forge are rich in sigillaria, whilst coals suitable for gas-making contain an abundance of ferns. From such like circumstances many geologists have concluded that there exists a direct relationship between the plants which have formed the coal and the quality of the coal derived from them; others, however, maintain strongly that these differences are due solely to the conditions under which the transformation into coal took place.

With reference to these debated points, I am able to put before you the result of a series of experiments, or chemical analyses, which have been recently published in the "Echo des Mines."

Chemical analyses of coal have been often made, and long lists are given in Bischoff's Chemical Geology," but I am not aware of any where the analyses of particular fossil plants have been given.

[*Translation of Extract from "L'Echo des Mines.*]

"It is generally believed that there exists a notable difference in the chemical composition between different vegetable species: nevertheless two varieties of nearly opposite kinds of wood, the oak and the fir tree, have given under the hands of M. Gottlieb, of Copenhagen, the following elementary composition:—

	C	H	O	Az	Ash.
Oak	50·16	6·02	43·36	0·09	0·37
Fir	50·31	6·20	43·08	0·04	0·37

The same similarity exists among the plants transformed

eminent French palæo-botanist, who has long and closely studied the fossil plants of his own immediate district—the coal basin of St. Etienne and the Loire—and has compared them with other European and American types.

The result of his labours has been the publication of a work, in which he asserts the possibility of determining the relative ages of the different beds of coal of any isolated basins by the examination of the paramount or prevailing species.

The importance which he attaches to this numerical preponderance of any group of plants is shown by the use he makes of it in his classification.

M. Grand'Eury has divided the Carboniferous Flora (with which he includes the Permian) conformable to his recognised order of development—into five *phases*—and these again are divided into zones marked by the advent of certain species and their numerical preponderance in any zone.

He classes, by their flora, the English coalfields in one great coal band, stretching eastwards from our shores, and including those of Flanders, Belgium, and Westphalia.

To the south of this line the isolated coal basins, such as those of Central and Southern France, belong to a phase of vegetation posterior to that exemplified by the English coalfields.

In the classification put forth by M. Grand'Eury, the Lower Coal Measures of Scotland are placed in the first or earliest *phase*, and the Lower and Middle Coal Measures of England in the middle zone of the second *phase*.

The coal beds of St. Etienne rank later in time, and are remarkable by the paucity of Lepidodendra and Sigillaria, and the relative abundance of Cordaïtes, tall growing trees (60 to 100 or 120 feet in height), allied to the conifers, whose *débris* are said to be the principal components of some of the thickest beds of this coal field.

Leaving this portion of the subject, I would ask your

Thus, the experiments of M. Carnot show that the age of the coal and the different circumstances which have ruled at its formation are not the only ones having influence over its properties. When all the conditions have been absolutely identical, the different vegetable species have produced coals of sensibly different qualities."

I do not suppose for a moment that the experiments detailed above, will settle the oft-debated question as to whether we are to seek in the nature of the plants themselves, or the conditions under which they were entombed, the explanation of their varying qualities.

Probably both views are partially correct; for while, under certain circumstances, richness in volatile matters may be rightly ascribed to the nature of the plants forming the coal, yet we cannot lose sight of the fact that beds of coal that have been greatly disturbed by earth movements may have lost some of their volatile substances owing to, as suggested by Bischof, the readier access of water which favoured the evolution of gases.

Other causes might be suggested for these differences, but their consideration at the present time would lead us into a very controversial region.

In conclusion, and by your permission, I will trespass for a few moments into another debateable land, and that is the consideration of the cause of the unique character of the carboniferous flora.

We know that at the present day distant parts of the world are distinguished by their peculiar vegetation and distinctive climate, a state of things which is in absolute contrast to that which obtained in the carboniferous epoch. Many speculations or hypotheses have from time to time been put forth to account for this singularity, but all have hitherto failed to wholly satisfy the conditions of the problem awaiting solution.

The structure of the plants which compose the vegetation

shows the absence of seasonal changes, and the family likeness which prevailed from the Equator to the Poles demonstrates that the same external influences with equal distribution of light and heat existed everywhere.

Various astronomical and terrestrial causes, which I shall not take up your time to enumerate, have been assigned to account for a climate so exceptional, at once humid and tropical, and co-extensive with the globe.

A theory in explanation, which was proposed some fifteen years ago by M. Blandet, has recently been revived, and has received the adhesion and support of several foreign savants. It is an adaptation of the nebular hypothesis of Laplace.

It is suggested that during the early periods of our earth's history the solar system presented a different aspect to what it does now. Other worlds than ours were undergoing changes, probably vaster far than any that our earth bears record of.

The sun itself was not then a bright and brilliant globe of well-condensed matter, but a luminous nebula, occupying a considerable place in space. From its larger size, its rays illuminated a larger extent of the earth's surface, so that no circle of latitude was in the position of having to accomplish the whole of its diurnal rotation in the dark.

What M. Blandet's theory demands is an increased diameter of the sun, with a less condensed state of its component matter, emitting less of light and of heat per unit of surface than at present. In this simple hypothesis seems to lie the secret of the climate of the carboniferous epoch.

Discussion upon the paper was deferred till a future meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XVIII. SESSION 1884-5.

WIGAN MEETING.

At the ORDINARY MEETING of the Members of the Society, held on Friday, May 1st, 1885, in the Mining School, Wigan;

H. HALL, Esq., H.M.'s Inspector of Mines, Vice-President, in the Chair.

NEW MEMBERS.

The following gentlemen were elected ordinary members of the Society :—

Mr. WILLIAM KEARSLEY, Colliery Manager, Tyldesley;

Mr. ISRAEL BARKER, Colliery Manager, Whit Lane, Pendleton.

ACCIDENTS IN MINES AND THEIR PREVENTION.

PART 1.—EXPLOSIONS.

BY Mr. J. S. BURROWS, M.E.

Discussion continued.

SHOT-FIRING.

The CHAIRMAN in opening the proceedings said that the first business of the meeting was to discuss Mr. J. S. Burrows' paper on the subject of Explosions in Mines, which

was read and partly discussed at the previous meeting in Manchester. He remarked that the paper contained much interesting matter, especially with reference to safety lamps and the use of gunpowder, and that the subject of explosions ought to be one of the utmost interest to mining engineers. He was therefore glad to see there was a good attendance at the meeting.

Mr. MARTIN observed that there were a great many in this part of the country who carried out the regulation of the Mines Act, as to explosives, by using them only when the persons ordinarily employed are out of the mines. In South Wales, and elsewhere, he saw from the newspapers, there had been a great deal of controversy, and a great many statements made as to the impossibility of carrying out such a regulation. Perhaps some of the mining engineers present, who had had practical experience of the matter, would give the meeting the result of their experience, stating the difficulties they had met with and how they had overcome them. He could say from his own knowledge of the practice in this part of the country that it was not impossible to carry on a colliery with this restriction; but if those who were actually doing the work would speak, perhaps it would be more authoritative. Some persons, no doubt, who used powder in this way were connected with mines that worked only one shift, but there were other cases where two shifts were worked and the regulation was carried out. The meeting would be glad to hear the arrangements in both cases.

Mr. GRIMKE said the pit that he was connected with was working two shifts, and, as a consequence, they found some difficulty in carrying out the legal requirement in this matter of firing shots when nobody was in the mine. It was a question what the "nobody" meant. Did it mean

that no one was to be in a particular division of the mine, or was the whole of the mine referred to? That was a question he would like to have answered.

Mr. TONGE said he had not found any difficulty in the matter; when shots could be placed in the coal in the day-time, and lighted after the men had left, and when, as the result of one shot, sufficient coal was dislodged for a man's work during next day; but he did not see how shot-firing could be confined to the time when the men were out of the pit, if it were necessary to use two or three shots in a shift.

Mr. GRIMKE, describing the process as carried out under his own observation, said that supposing a man went to work at six in the morning, he would find sufficient coal blown down to occupy him for the day. That done with, he would proceed to prepare for and drill a hole for the next shot. When he came out at three o'clock in the afternoon, the firemen and shot-lighters went round, rammed the shots and fired them. These shot-lighters divided the mine into three parts, and did all their work whilst the miners were out of the pit.

The CHAIRMAN: Is that the result of practice?

Mr. GRIMKE: Oh, yes; that is done regularly in one of our mines.

Mr. BURROWS: If anyone thinks it impossible to use powder between the shifts, and when the men are out of the mine, perhaps he will state his objection and the difficulties he finds or anticipates. Then those who carried out the law could perhaps help him out of his difficulty.

Mr. TONGE: There is one slight difficulty I can fancy. I conceive it would be very much more easy to do without shot-firing whilst the men are at work when the mine is of

was read and partly discussed at the previous meeting in Manchester. He remarked that the paper contained much interesting matter, especially with reference to safety lamps and the use of gunpowder, and that the subject of explosions ought to be one of the utmost interest to mining engineers. He was therefore glad to see there was a good attendance at the meeting.

Mr. MARTIN observed that there were a great many in this part of the country who carried out the regulation of the Mines Act, as to explosives, by using them only when the persons ordinarily employed are out of the mines. In South Wales, and elsewhere, he saw from the newspapers, there had been a great deal of controversy, and a great many statements made as to the impossibility of carrying out such a regulation. Perhaps some of the mining engineers present, who had had practical experience of the matter, would give the meeting the result of their experience, stating the difficulties they had met with and how they had overcome them. He could say from his own knowledge of the practice in this part of the country that it was not impossible to carry on a colliery with this restriction; but if those who were actually doing the work would speak, perhaps it would be more authoritative. Some persons, no doubt, who used powder in this way were connected with mines that worked only one shift, but there were other cases where two shifts were worked and the regulation was carried out. The meeting would be glad to hear the arrangements in both cases.

Mr. GRIMKE said the pit that he was connected with was working two shifts, and, as a consequence, they found some difficulty in carrying out the legal requirement in this matter of firing shots when nobody was in the mine. It was a question what the "nobody" meant. Did it mean

Mr. C. PILKINGTON said he considered that in a thin mine, where ventilation was carried round the faces, it was a distinct disadvantage to have the shots fired when men were out of the mine, because of the possibility of the air-ways getting stopped up with the coal or dirt. If the mine was a thick one, there was less difficulty; but there were mines where it might be dangerous to carry out the rule.

Mr. WINSTANLEY said the fears expressed by Mr. Cockson were realised in a mine that he was acquainted with. A shot was fired in the night by the two regular shot-lighters, and it lighted a blower of gas. Whether the men neglected it, or lost their nerve he could not say, but they did not give timely notice for assistance, and the consequence was that the colliery was set on fire and had to be flooded.

Mr. HILTON said he knew it was held by some people that it was safer to have more men down than just the shot lighters, but for his part he preferred to have only a few down. In the case mentioned by Mr. Winstanley, had there been twenty men down they might all have lost their nerve, and if they feared an explosion they would all go, no matter how large the number of men might be.

The CHAIRMAN: Do you find any special difficulty in carrying out the system?

Mr. HILTON: We have not done so yet.

The CHAIRMAN: Do you mind telling us whether you have any colliery where blasting of the stone has to be done as well as the coal, and in which you carry on the system of firing when the men are out?

Mr. HILTON: Yes, we have.

The SECRETARY (Mr. Martin) said the interest in this subject has extended recently beyond this country, and is

considerable thickness. But a difficulty presents itself when the seam is very thin. It would then be difficult for a man to get sufficient coal by one shot.

Mr. GRIMKE: The answer to that is simple. You would give them more shots and more working face for each man. If it is found that a shot has not acted, another place has to be found for the man, and that part of the mine in which he usually works remains idle until the next day. Consequently there have to be a few more vacant places under the new system than under the old, because formerly the men would fire one shot after another in the daytime.

Mr. COCKSON said the system of firing shots when the main body of the workmen had left the mine had doubtless many advantages, but it seemed to him that there was one serious risk attending it which had not been mentioned by previous speakers. There was a danger of fire, occurring after a shot, not getting extinguished under the system now in vogue. Under the old system, if the brattice, timber, or coal caught fire, there were plenty of men at hand to put out the flame; but now it appeared to him there was a greater risk of the fire getting such a hold, before help arrived, that the mine might be destroyed. He did not wish it to be understood that he was opposed to the system of firing when the men were out of the mine as this system was adopted in certain mines with which he was connected, but he did think that putting aside the objection that had been raised of a man losing his day's work through the shot having failed to go off, the extra risk of setting fire to the mine was a serious one, and one that ought not to be altogether overlooked.

Mr. PICKARD said he thought that if proper supervision were exercised by the firemen or shot-lighters, the risk of firing the mine was reduced to a minimum.

the use of powder to the night-time, when the mine was not being worked, it was better as regards the saving of both life and property. That there was some difficulty in the matter he was ready to admit, but his feeling was that the sooner they could see their way to the non-use of powder altogether the better. A sudden shock might open the pores of the mine and let in the explosive gas, and lead to great destruction of life and property.

Mr. BURROWS, replying on the discussion, said he was much pleased with the tone of the observations which had been offered, and to find that there was so little opposition to the system which he had advocated in his paper. The objections raised were theoretical rather than practical, as to the danger from fire, the shot-lighters leave the date on the top of the coal they have just blown, to show that they have examined the place after the shot has gone. It was about seven years since the system was commenced in one of the mines that he was connected with, and it had answered admirably. To begin with they had the co-operation of the workmen. He took the precaution, before putting it in force, to talk with the men on the subject when going round the pit. They raised little objection when they saw how much safer it would be. They thought it would be worse as regards wages for them, but their fears were now removed. The system was carried out with ease, and he thought rather to their advantage than otherwise, and also to that of the proprietors. There were five shot-firers. Work was begun at six in the morning, and the men came out at three o'clock in the afternoon. The shot-lighters went down about half-past nine, and during the day they did a lot of datalling. They also looked over the miners' places and saw where the shot-holes were being put, and if dissatisfied they refused to fire such shot, so that between them the proper place was agreed upon. After the

workmen have left, the shot-lighters go round and fire the shots against the air. The work is so arranged that the men meet each other, so that if at the end of an hour or an hour and a half any of them fail to appear, the others know that something is wrong, and they proceed to find it out. As a matter of fact, however, they always did meet, and came out of the mine about six o'clock. The rest of the datallers went down about eight o'clock, and came up between five and six next morning as the miners went down. When two turns were worked the colliers who went down at six in the evening found their places ready. They proceeded to remove the coal, and then drill holes and prepare for the shots which should provide work for the next turn. He thought the use of powder had had as much to do with the explosions of the past as anything, and that the maximum of safety consistent with its use was reached by firing the shots when the mine was denuded of its ordinary workmen. His experience was that the men themselves preferred to work in mines where such a system was carried out, on the ground that their lives were safer under such circumstances.

Mr. MARTIN asked how many shots were fired in one night?

Mr. BURROWS: Perhaps 130 or 150 every night.

Mr. MARTIN: Your custom is for the shot-firers to fire against the air?

Mr. BURROWS: Yes, to keep the smoke away from them.

Mr. PILKINGTON considered that the necessity of providing two places for each collier—that was what it practically amounted to in thin mines—was an objection, because there would have twice the area of mining workings to keep perfectly safe, and they all knew that more lives were lost by falls of roof than by explosions.

Mr. BURROWS said he did not see that two places would require to be kept for each miner. As a matter of fact, it was not so; and under the new system better coal was sent out than before, and the men were obliged to attend more regularly to their work. Instead of working half a day, and thinking he would make up for it next day, he was now compelled to clear away his day's work of coal, and then prepare his place for the shot for next day's work by holing, cutting, and drilling.

Mr. BRYHAM said it had been his practice for seven or eight years to do as Mr. Burrows had described. In the Pemberton mines that he had to do with, they fired 280 shots per week, in the night, and the same quantity of coal was got as there was with 500 shots fired previously in the daytime; thus showing that as much coal could be produced by firing shots in the night-time as in the daytime. Formerly they used to be firing shots all the day over.

Mr. MARTIN: Seeing that the holing and cutting is so much larger, has there been any improvement in the quality of coal?

Mr. BRYHAM: Yes, with blasting as described; but my experience has been that it is not so where hammer and wedges are used instead of powder.

Mr. PICKARD thought it was obvious that a greater percentage of small coal would be got by firing in the daytime—that was, by firing more shots and smaller ones as in the past without holing or cutting—than by firing large shots at night, when the coal is well holed and cut.

The CHAIRMAN said it had recently been brought to his notice by a fireman in the district that it frequently occurred, that after they had done their best to examine a narrow place, and found no gas, and then lighted the shot, as much as ten or twelve yards of flame came back. One

workmen have left, the shot-lighters go round and fire the shots against the air. The work is so arranged that the men meet each other, so that if at the end of an hour or an hour and a half any of them fail to appear, the others know that something is wrong, and they proceed to find it out. As a matter of fact, however, they always did meet, and came out of the mine about six o'clock. The rest of the datallers went down about eight o'clock, and came up between five and six next morning as the miners went down. When two turns were worked the colliers who went down at six in the evening found their places ready. They proceeded to remove the coal, and then drill holes and prepare for the shots which should provide work for the next turn. He thought the use of powder had had as much to do with the explosions of the past as anything, and that the maximum of safety consistent with its use was reached by firing the shots when the mine was denuded of its ordinary workmen. His experience was that the men themselves preferred to work in mines where such a system was carried out, on the ground that their lives were safer under such circumstances.

Mr. MARTIN asked how many shots were fired in one night?

Mr. BURROWS: Perhaps 130 or 150 every night.

Mr. MARTIN: Your custom is for the shot-firers to fire against the air?

Mr. BURROWS: Yes, to keep the smoke away from them.

Mr. PILKINGTON considered that the necessity of providing two places for each collier—that was what it practically amounted to in thin mines—was an objection, because they would have twice the area of mining workings to keep perfectly safe, and they all knew that more lives were lost by falls of roof than by explosions.

Mr. BURROWS said he did not see that two places would require to be kept for each miner. As a matter of fact, it was not so; and under the new system better coal was sent out than before, and the men were obliged to attend more regularly to their work. Instead of working half a day, and thinking he would make up for it next day, he was now compelled to clear away his day's work of coal, and then prepare his place for the shot for next day's work by holing, cutting, and drilling.

Mr. BRYHAM said it had been his practice for seven or eight years to do as Mr. Burrows had described. In the Pemberton mines that he had to do with, they fired 280 shots per week, in the night, and the same quantity of coal was got as there was with 500 shots fired previously in the daytime; thus showing that as much coal could be produced by firing shots in the night-time as in the daytime. Formerly they used to be firing shots all the day over.

Mr. MARTIN: Seeing that the holing and cutting is so much larger, has there been any improvement in the quality of coal?

Mr. BRYHAM: Yes, with blasting as described; but my experience has been that it is not so where hammer and wedges are used instead of powder.

Mr. PICKARD thought it was obvious that a greater percentage of small coal would be got by firing in the daytime—that was, by firing more shots and smaller ones as in the past without holing or cutting—than by firing large shots at night, when the coal is well holed and cut.

The CHAIRMAN said it had recently been brought to his notice by a fireman in the district that it frequently occurred, that after they had done their best to examine a narrow place, and found no gas, and then lighted the shot, as much as ten or twelve yards of flame came back. One

fireman wrote to say that in one case he fired a shot in a place ten or twelve yards from the opening; he first examined it carefully, and found no trace of gas, and none had been seen before the shot was fired on previous days. But when the shot went off, immediately a flame burst forth, and extended to the opening. On re-entering to ascertain the cause, he found a small blue flame behind the coal that had fallen, which of course he at once put out. After giving seven or eight instances of the same thing occurring, the writer went on to explain that his supposition was that when the shot went off, the coal broke, and gas escaped from the opening that was made. Before this man became a shot-lighter he thought there was no danger in using gunpowder, but now he has formed the opposite opinion. For his own part he thought there was an advantage in shot-firing when the men were out of the mine. A larger quantity of round coal was obtained from firing in that way than by firing in the daytime under the old system.

A brief discussion followed on the subject of safety lamps.

Mr. Burrows was of opinion that a Mueseler or a Marsaut was preferable to the Davy.

Mr. Hilton expressed approval of the use of the Davy lamp, with a glass cylinder to protect the lower part of the gauze, and the Smethurst shield to protect the upper part. By an arrangement of this kind the wind could not so readily impinge on the flame, and in the event of wishing to test the presence of gas, or light a shot, the glass cylinder could be lifted. Greater safety was thus promoted at the expense of a little less light.

ON THE QUESTION OF THE AGE OF THE ROCKS OF ST. DAVID'S.

By Mr. R. T. Burnett, F.G.S.

In the present paper I do not propose to lay before the Society anything more than a short statement of the history of the question as evolved by the various discussions which have from time to time taken place before the London Geological Society, to the transactions of which I am mainly indebted for the diagrams and extracts which I have the honour of bringing before you.

The earliest account of the Rocks of St. David's were published in 1814, by Dr. Kidd, in Vol. II. of 1st Series of Geological Transactions, wherein he states that "in some instances the rocks were 'stratified' and in others 'unstratified;' that the hills or rocky summits bear no mark of regular stratification, but appear as so many nuclei, about which is arranged a very curiously diversified series of highly-inclined strata of a kind of slate."

The next notice is by Sir Henry de la Beche, in a paper read before the Geological Society, wherein he separated the rocks into "Trap" and "Greywacke," and he was inclined to regard Trap as intruded amongst other rocks, subsequent to their consolidation.

In 1839, Sir R. J. Murchison described the Trap as "'stratified,' alternating with sedimentary rocks and "amorphous masses, which have burst through the strata. "Amongst older strata Trap rocks were thick bedded, "coarse, felspathic conglomerates, containing fragments of "schists and shales which range N.E. to S.W. in alignement "with the other ridges of amorphous Trap."

London: Royal Society. Proceedings, No. 236, Vol. XXXVIII.—*From the Society.*

Manchester: Association of Employers, Foremen, and Draughtsmen. Pamphlet. The Turbine as a Water Motor, by Mr. A. Rea.—*From the Association.*

Scotland: Mining Institute of Scotland. Transactions, Part 9, Vol. VI.; Part 1, Vol. VII.; Rules and List of Members, 1884-5; and Catalogue of Library.—*From the Institute.*

Australia: Gold Fields of Victoria. Reports of Mining Registrars, December, 1884.—*From the Government.*

U.S.A., Philadelphia: Journal of the Franklin Institute, No. 713, Vol. CXIX.—*From the Institute.*

Ditto, Academy of Natural Sciences. Proceedings, Part 1, 1885.—*From the Academy.*

Ditto, United States Geological Survey. Third Annual Report, 1881-82, by J. W. Powell, Director; Ditto, Monographs, Vol. III. (Geology of the Comstock Lode); Ditto, Atlas to the above, Becker.—*From the Director of the Survey.*

Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft. 4 Heft, 36 Band; 1 Heft, 37 Band.—*From the Society.*

Dresden: Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden. July to December, 1884.—*From the Society.*

Pisa: Atti della Società Toscana di Scienze Naturali. Processi Verbali, Vol. IV., 22 Mars, 1885.—*From the Society.*

Roma: Atti delle Reale Accademia dei Lincei.—Rendiconti. Fasc. 9-11, Vol. I., 1885.—*From the Academy.*

St. Petersburg: Comité Géologique. Institut des Mines. Mémoires, No. 1, Vol. II.; Proceedings, Parts 8-10, 1884; Ditto, 1-4, 1885.—*From the Minister of Domains.*

The Hon. Secretary called the attention of the members to the publications which had been received since the last meeting, including important works by the Geological Survey of the United States. Amongst the latter was a valuable monograph on the Geology of the Comstock Lode, an important metalliferous region of Nevada.

Ancient Rocks in the Vicinity of St. David's, wherein he confidently asserts that "the rocks coloured as syenite are "of pre-Cambrian age," and he maintains that "they are "bedded rocks in some parts, partly metamorphosed," and he then affirmed that "they were covered unconformably "by the Cambrian series." He also stated as follows: "Directly under the city of St. David's, or rather under "its eastern portions, are some massive beds of quartz "conglomerates, very compact in structure, but alternating "with dark green shales with a strike from N.W. to S.E. "These have a thickness as we follow them directly east- "ward from this spot of about 4,000ft. The ridge formed "by these rocks underlies the whole of the remaining "strata of the district, being the axis on which the "Cambrian and other rocks are supported. The beds "forming the Harlech or Longmynd group, consisting of "green shales, conglomerates, and purple, red, and green "sandstones and slates, are seen on both sides of the ridge, "and are therefore indications that they once extended "over it, but they have been subsequently denuded off. "Many of the beds between Ramsey Sound and St. David's "are considerably altered, but there are no intrusive masses "amongst them of any importance. The great mass on the "east of Ramsey Sound, coloured as greenstone in the "Survey maps, is *nothing more than bedded Cambrian rocks* "*altered*. On the east side of the axis the same order of "succession occurs as on the westward side, but the beds "are less altered."

In November, 1876, Dr. Hicks read another paper before the Geological Society, which he entitled "On the pre- "Cambrian (Dimetian and Pebidian) Rocks of St. David's," wherein he alludes to the Survey map of 1857, and its colouring of syenite and felstone. He stated "that when "he was making sections in 1864 of the so-called syenite

" he noticed portions of it made up of altered rock, in which " the bedding was quite distinct, and that on further " examination it seemed clear that the syenite did not " penetrate any of those beds." In this paper Dr. Hicks " pointed out that the masses of rock forming Cambrian " conglomerate were derived from rocks apparently identical " with those forming this ridge. He said this discovery led " Mr. Salter and myself to suspect that the ridge of so-called " syenite was a portion of what had previously been a " pre-Cambrian island." Dr. Hicks now proposed to divide the rocks into two distinct series: "*Dimetian* for the lower " series, so called because that being the ancient name for a " kingdom which included that part of Wales. *Pebidian* " for the upper series, so called because this being the name " of the division or hundred in which these rocks are chiefly " exposed.

"Up to this time, no name had been given to rocks in " England or Wales, which occupy earlier position than the " Cambrians."

Dr. Hicks asserted that the rocks composing the ridge consisted chiefly of " compact quartziferous beds, altered " shales and limestones in the lower series, and of altered " conglomerates and shales in the upper series." Further, " that the two series are everywhere unconformable to one " another." Also, " that the Cambrian conglomerates over- " lap them irregularly; in some places entirely covering " over the upper series.

" The conglomerates also are almost altogether made up " of pebbles derived from the underlying rock.

" As to the Dimetian, the rocks which compose this series " are chiefly compact quartz-schists, chloritic schists, " and indurated shales. The most highly crystalline beds " occur to the north of St. David's, in which the quartz

"seems to be nearly perfectly crystalline. Other beds "between this point and St. David's are also very much "altered, but, as we go further south the rock seems to be "less highly metamorphosed." None of the "shales of St. "David's contain much calcareous matter, and they do not "effervesce with acid, but these shales and schists at "Porthlisky include some of the more compact quartz-"schists, and effervesce most freely, and, on analysis, show "the presence of frequently over 20 per cent. of carbonates."

Dr. Hicks observes:—"I have not yet discovered any-"thing in these beds of a decidedly organic nature," and that "the quartz-schists have generally a greenish or a "purplish tint, and the surface of the bedding and joints a "soft and greasy feel."

In speaking of the Pebidians, he says:—"They rest "everywhere unconformably on the Dimetians. They "extend along both sides of the ridge, with the exception "of a small area at the north-east end, where they are cut "off towards the south end by faults. They vary in thick-"ness, at some places less than 500ft., at others over 2000ft. "These rocks, like the Dimetians, are greatly metamor-"phosed, and consist chiefly of indurated shales, often "porcelainitic in character. In the more compact, stratifi-"cation is generally indicated by narrow dark lines, which "give the rock a rather pretty banded appearance. The "beds are also frequently intersected by closely approxi-"mated joints. The lower beds of the series, or those "resting immediately on the Dimetian area, are hard "compact conglomerates, in which, however, from the great "change which they have undergone, the distinct outline of "the pebbles is, for the most part, lost. The conglomerates "are chiefly composed of masses of quartz and altered shale, "or such masses as might have been derived from the "underlying rocks, very closely cemented together, a test

" he noticed portions of it made up of altered rock, in which " the bedding was quite distinct, and that on further " examination it seemed clear that the syenite did not " penetrate any of those beds." In this paper Dr. Hicks " pointed out that the masses of rock forming Cambrian " conglomerate were derived from rocks apparently identical " with those forming this ridge. He said this discovery led " Mr. Salter and myself to suspect that the ridge of so-called " syenite was a portion of what had previously been a " pre-Cambrian island." Dr. Hicks now proposed to divide the rocks into two distinct series: "*Dimetian* for the lower " series, so called because that being the ancient name for a " kingdom which included that part of Wales. *Pebidian* " for the upper series, so called because this being the name " of the division or hundred in which these rocks are chiefly " exposed.

"Up to this time, no name had been given to rocks in " England or Wales, which occupy earlier position than the " Cambrians."

Dr. Hicks asserted that the rocks composing the ridge consisted chiefly of "compact quartziferous beds, altered " shales and limestones in the lower series, and of altered " conglomerates and shales in the upper series." Further, " that the two series are everywhere unconformable to one " another." Also, "that the Cambrian conglomerates over- " lap them irregularly; in some places entirely covering " over the upper series.

" The conglomerates also are almost altogether made up " of pebbles derived from the underlying rock.

" As to the Dimetian, the rocks which compose this series " are chiefly compact quartz-schists, chloritic schists, " and indurated shales. The most highly crystalline beds " occur to the north of St. David's, in which the quartz

delivered two papers before the Geological Society, "On the supposed pre-Cambrian Rocks of St. David's," in which he reviewed the evidence I have already laid before you, and stated that the object of his communication was to discuss the evidence for the assertion that pre-Cambrian rocks exist at St. David's, and also to lay before the Society an outline of what appeared to him to be the true structure and geological history of the district.

In these papers Dr. Geikie has divided his subject into two parts; the first one he terms controversial, and deals with the alleged Dimetian, Arvonian, and Pebidian groups. In the second part he deals with the order of succession of the rocks, geological structure of the district, the granite, quartz porphyry, and accompanying metamorphism, and the diabase dykes and intrusive sheets. In dealing with the Dimetian, he says: "The rocks are regarded by Dr. "Hicks as great, bedded, metamorphic, pre-Cambrian "series, later in age than the ancient Gneiss of the Hebrides, "subdivided by him into two groups, a lower consisting of "the massive granitoid and gneissose rocks of Bryn-y-"Garn, St. David's; and an upper, composed of the so "called quartz schists of Porthlisky." Dr. Geikie adds, in reading Dr. Hicks's paper, "I have been unable to find "a description of, or references to the numerous natural "sections where the relations of the crystalline rock of the "ridge to the surrounding mineral masses are displayed."

Dr. Geikie, began his work by examining the ridge of which Bryn-y-Garn is the crest, but was "unable to detect "the remotest resemblance to foliation of gneiss or schist "or any alteration of other rocks." On the contrary, he "avers it everywhere retains the same general aspect and "familiar external characters of a massive eruptive rock." It was not until he had "diligently hammered every knob "and boss of rock in the whole district, without discovering

" any other structure than that of an eruptive mass," that he was "driven to abandon the idea of a bedded structure " and metamorphic origin for the central rock of the ridge." Dr. Geikie maintained "the admirable section of the coast " line, reveals the structure of the rock so completely that " he could only ask himself the question, how such a rock " could ever by any possible stretch of imagination, be " credited with a bedded structure and a metamorphic origin?" Dr. Geikie says that this rock "to the naked eye " appears everywhere to be thoroughly crystalline and " granitic in structure. The numerous rocky bosses upon " the ridge S.W. of St. David's, and still more the long " coast section from Porthlisky eastward, present a massive " rock entirely destitute of definite structure, but traversed " by irregular joints which divide it into blocks as in any " ordinary granite. Had the rock of St. David's been one " which might be classed with gneisses and schist, it would " have revealed proofs of foliation. I searched most care- " fully every exposure of the rock, and have since examined " microscopically a series of specimens taken from all parts " of the ridge, without detecting, either on the large or the " small scale, any, even the most distant, approach to a " foliated structure. Occasionally veins of a paler colour " and finer texture ramify through the rock, varying in " width from an inch to more than a foot. Every one " familiar with a large mass of granite will recognise such " veins as characteristic features of it." Dr. Geikie alleges that the only distinct species of rock he could discover in the mass was a dull greenish diabase or wacke, "in the form " of dykes and veins, varying in breadth from a few inches " to several feet, traversing the granite irregularly in all " directions, and that where they run parallel, and have a " slight hade in the same direction, they produce resem- " blance to an alternation of beds." Dr. Geikie further

contradicts Dr. Hicks's early allegation of abundant shales among the crystalline rocks of the ridge, and says he believes him to have been deceived by "the greenish decayed material "filling the partially open joints sometimes caused by the "diabase dykes and veins." He repeats, in the most emphatic manner, that after an exhaustive search over the whole, he "could not find the slightest trace of any shale, schist, "quartzite, gneiss, or other stratified rock bedded with that "composing the ridge between Bryn-y-Garn and the head-"lands south of Porthlisky."

In dealing with the Arvonian, Dr. Geikie reviews Dr. Hicks's evidence, and says "that as regards the evidence to "be obtained at St. David's itself there is no foundation "whatever, for the institution of a separate group under "the name of 'Arvonian,' because the rocks so called by "Dr. Hicks are portions of his Pebidian group invaded and "altered by a central core of granite and abundant dykes "or bosses of quartz porphyry."

After shortly dismissing the "Arvonian" group, Dr. Geikie says that, with regard to the Pebidian group, "I "accept generally the lithological descriptions here given," and that "there can be no doubt that the group is almost "entirely of volcanic origin, formed principally of various "tuffs, with bands of olivine, diabase, and occasionally "intrusive masses of quartz porphyry," and that "the "volcanic nature of these rocks was clearly recognised by "my predecessor, Sir A. C. Ramsay, in his original map "and section, and his early MS. report on the St. David's "area, and that he afterwards allowed this view to be set "aside in favour of the opinion that the peculiar bedded "rocks on the west side of the granite ridge are 'altered "'Cambrian' strata, through which intrusive greenstones "have been injected. It is this view which is expressed "upon the second and latest edition of the Survey map. I

"any other structure than that of an eruptive mass," that he was "driven to abandon the idea of a bedded structure "and metamorphic origin for the central rock of the ridge." Dr. Geikie maintained "the admirable section of the coast "line, reveals the structure of the rock so completely that "he could only ask himself the question, how such a rock "could ever by any possible stretch of imagination, be "credited with a bedded structure and a metamorphic origin?" Dr. Geikie says that this rock "to the naked eye "appears everywhere to be thoroughly crystalline and "granitic in structure. The numerous rocky bosses upon "the ridge S.W. of St. David's, and still more the long "coast section from Porthlisky eastward, present a massive "rock entirely destitute of definite structure, but traversed "by irregular joints which divide it into blocks as in any "ordinary granite. Had the rock of St. David's been one "which might be classed with gneisses and schist, it would "have revealed proofs of foliation. I searched most care-"fully every exposure of the rock, and have since examined "microscopically a series of specimens taken from all parts "of the ridge, without detecting, either on the large or the "small scale, any, even the most distant, approach to a "foliated structure. Occasionally veins of a paler colour "and finer texture ramify through the rock, varying in "width from an inch to more than a foot. Every one "familiar with a large mass of granite will recognise such "veins as characteristic features of it." Dr. Geikie alleges that the only distinct species of rock he could discover in the mass was a dull greenish diabase or wacke, "in the form "of dykes and veins, varying in breadth from a few inches "to several feet, traversing the granite irregularly in all "directions, and that where they run parallel, and have a "slight hade in the same direction, they produce resem-"blance to an alternation of beds." Dr. Geikie further

Dr. Geikie asserts that the conformability between the "Pebidian" rock and the "conglomerate which Dr. Hicks "makes to be the base of the Cambrian system likewise "disappears on examination." In reference to Dr. Hicks's statement that the Cambrian conglomerates are largely made up of the underlying pre-Cambrian rocks, he feels himself "warranted, after careful examination of the "conglomerate belt, in stating confidently that it *contains "not a single pebble of the characteristic granite of the St. "David's ridge,"* and in support of this he gave percentages of stones taken by Mr. Peache on the west side and by himself on the east side of the fold, "showing," as he states, "of the component pebbles, 95 per cent. are of "quartzite or quartz." Further, "that the only fragments "of undoubtedly local derivation are the few pieces of "diabase which would come from some of the lavas of a "volcanic series below." In concluding this part of his paper, he declares "that the map of the St. David's district, "as surveyed by De la Beche, Ramsay, and Aveline, is, *in "its essential features, correct.*"

The second part of Dr. Geikie's paper, the heads of which have been mentioned, deals "principally with the result "of the microscopic investigation of the rocks collected by "him at St. David's," a hundred slides of which Dr. Geikie had studied, together with a large number "cut from rocks "of other regions, for the purpose of comparison," which, he asserts, tend to support the views of the first part of his paper. He states "that the coast sections and repetition of "the strata on two sides of an axis of plication, combine to "furnish most satisfactory data, for compiling a vertical table of the rocks" which he names, as follows, in descending order:—

4. Purple and greenish grits, sandstones, and shales.

3. Green and red shales and sandstones, tuffaceous in parts.

2. Quartz conglomerate.

1. Volcanic group (tuffs, schists, lavas, &c.)

Each of the foregoing are dealt with in too great a detail to be now laid before the Society. He considers "the "volcanic group to be the oldest visible portion of the "Cambrian system in this district, if not the oldest group of "truly volcanic masses in Western Europe. They are the "oldest, of which precise stratigraphical place in the "geological record is known."

In conclusion, he assumes "that in the lower Cambrian "period active volcanic vents, probably submarine, existed "in the west of Pembrokeshire, showering volcanic detritus "and occasional streams of lava, until volcanic material to "the thickness of 1800 feet had accumulated. As volcanic "activity died out, sedimentation was resumed, and the "Harlech and remainder of the Cambrian system were "deposited. At a later period the whole was subject to "disturbance, the effect of which was to throw them into an "arch, and to bend this arch into an isocline towards the "north-west. The strata underwent foliation; subsequently, "the south-eastern side of the fold was invaded by the "'rise' of a mass of granite with the usual peripheral "quartz-porphyrys. Accompanying and outlasting this "intrusion, metamorphism went on, changing felsitic tuffs "or shales into flinty translucent masses, superinducing in "them a finely crystalline structure, with a development of "porphyritic felspar crystals, and threads of crystalline "quartz.

"The last episode would be that of forming the diabase "dykes, which represent the third and final outbreak of "eruptive rocks in the St. David's district. These dykes

"rise through the central core of granite, as through "an old area of weakness."

In the month of January, 1884, the Rev. J. F. Blake, M.A., F.G.S., read a paper before the Geological Society, which is entitled "*On the Volcanic Group of St. David's*," in which he stated that, "finding himself in accord with neither "Dr. Hicks on the one hand, nor with Dr. Geikie on the "other, he could not refrain from offering to the Society the "evidences on which his conclusions were based, and that "the result of his observations might be thus briefly "stated:—All the rocks which have been designated "Dimetian, Arvonian, and Pebidian, round and near the "city of St. David's, belong to one volcanic series, whose "members are those usually recognised in eruptive areas, "and whose age is anterior to and independent of the true "Cambrian epoch."

In concluding his paper and reviewing the evidence he had adduced, he said that he held a view "that the whole "series were of an essentially igneous character, that they "seemed united into a connected whole, and such he believed "them to be, a belief rendered more probable by the known "association of similar rocks in other volcanic areas of more "recent origin."

The discussion, which followed this paper was, on the whole, adverse to Professor Blake's theory. Dr. Hicks "appreciated the stratigraphy, but did not accept the "petrology, and thought that Professor Blake had not "proved the connection between the granitoid Dimetian and "the overlying volcanic series, and that he had omitted the "Clegyr Bridge breccias, and others near Nun's Well." He further pointed out that Professor Blake "was distinctly "opposed to Dr. Geikie's principal tenets, including the "evidence of intrusion of the granitoid series, and the great "fold of the volcanic series."

3. Green and red shales and sandstones, tuffaceous in parts.

2. Quartz conglomerate.

1. Volcanic group (tuffs, schists, lavas, &c.)

Each of the foregoing are dealt with in too great a detail to be now laid before the Society. He considers "the "volcanic group to be the oldest visible portion of the "Cambrian system in this district, if not the oldest group of "truly volcanic masses in Western Europe. They are the "oldest, of which precise stratigraphical place in the "geological record is known."

In conclusion, he assumes "that in the lower Cambrian "period active volcanic vents, probably submarine, existed "in the west of Pembrokeshire, showering volcanic detritus "and occasional streams of lava, until volcanic material to "the thickness of 1800 feet had accumulated. As volcanic "activity died out, sedimentation was resumed, and the "Harlech and remainder of the Cambrian system were "deposited. At a later period the whole was subject to "disturbance, the effect of which was to throw them into an "arch, and to bend this arch into an isocline towards the "north-west. The strata underwent foliation; subsequently, "the south-eastern side of the fold was invaded by the "'rise' of a mass of granite with the usual peripheral "quartz-porphyrys. Accompanying and outlasting this "intrusion, metamorphism went on, changing felsitic tuffs "or shales into flinty translucent masses, superinducing in "them a finely crystalline structure, with a development of "porphyritic felspar crystals, and threads of crystalline "quartz.

"The last episode would be that of forming the diabase "dykes, which represent the third and final outbreak of "eruptive rocks in the St. David's district. These dykes

Welsh areas. Had he done so, it would probably have prevented him from making many of the statements contained in his paper, and of committing serious errors which Dr. Hicks now feels compelled in self-defence to point out." Dr. Hicks said "that the controversy causes the views of the Survey to appear at variance with those outside the Survey, who had for some years devoted much of their time to the examination of the pre-Cambrian questions in Britain. This, to say the least of it, was unfortunate." Dr. Hicks then alluded to the corrections ıggested in his previous papers which should be made in ıe map, and said "that the patch coloured as syenite and felstone, consisting of granitoid rocks, porphyrite quartz-felsites, &c., are of pre-Cambrian age, and therefore cannot possibly be intrusive in the Cambrian rocks as indicated on the maps." Dr. Hicks alluded to other areas, ıith which we need not here deal. The extensive area oloured as *altered Cambrian* was stated by him to contain ocks unlike those classed as Cambrian, and he said he had given evidence to show that the latter rested unconformably on the so-called altered Cambrian, tending to prove that it was necessary to class the latter as of pre-Cambrian age." He said he had pointed out "that the long patch of so-called intrusive greenstone consisted mainly of acid breccias, but with a few basic dykes, sheets, and ashes, instead of being basic rocks at all, were composed of acid types of rocks, mainly porphyritic, old rhyolites, breccias, &c." In this present paper Dr. Hicks vished to call attention to the last two paragraphs of Dr. Ieikie's paper, "because they touched the essence of the disagreement between his views and those of the Survey. 'There it is maintained that the granitoid rocks, their 'former syenite (Hicks's Dimetian), are intrusive in the "Cambrian rocks." Dr. Hicks holds "that they are the

Professor Blake replied to Dr. Hicks's criticisms of his map, and said "they would not affect his views."

During the month of May, 1884, Dr. Hicks delivered another paper before the Geological Society, entitled "On the pre-Cambrian Rocks of Pembrokeshire," with special reference to the St. David's District." The paper was a very lengthy one, and can only be dealt with here so far as it affects his reply to Dr. Geikie. In his introduction Dr. Hicks stated that his previous papers of 1876, 1878, and 1879 dealt with the pre-Cambrian rocks so far as they were then known. "Since then he had obtained much information "regarding them, highly confirmatory of his previous "conclusions, and showing that the main points he then "insisted upon were correct. Some evidence had, however, "caused him to adopt minor modifications, which he was "quite prepared to expect, as further researches were being "carried on in that and other areas. The growth of the "question had been *a process of development* during a course "of years. Of this he was not ashamed, as his sole object "had been to arrive at the truth concerning these rocks. "On the other hand, he was always anxious to correct errors "when made clear, as the result of fuller information by "those whose special experience enabled them to do so. "The information now submitted had accumulated since his "last paper of 1879, and had been reserved only that it "might be placed in a more complete manner before the "Society. Dr. Geikie's paper had compelled him "to "re-examine, and therefore to refer again to many points." Dr. Hicks thinks "that before the Director-General had "claimed the works of his predecessors to be correct, he "should have seriously analysed any apparently conflicting "evidence brought forward since then, and should have "endeavoured to have made himself thoroughly acquainted "with the nature and behaviour of these rocks in all the

Dr. Hicks considers that the term "granitoidite" suggested by Professor Bonney is the best applicable to these rocks as exhibited at St. David's.

One thing is certain—concludes Dr. Hicks on this point—that the Dimetian at St. David's is not, as asserted by Dr. Geikie, a "central boss of eruptive granite with associated "peripheral dykes, elvans, or amorphous intrusions of "quartz-porphry, which has been protruded through the "Cambrian strata. And this is the main point contested."

With regard to the *Arvonian* rocks, Dr. Hicks contends "that they like the Dimetian are older than the Cambrian "conglomerates, because the Cambrian conglomerates con-"tain rolled fragments which cannot be differentiated from "the rocks," and further, "because the conglomerates "repose unconformably upon them, and are almost entirely "built up of materials which could only come from such "rocks. In the lowest Pebidian breccias, fragments of the "peculiar quartz-felsites, indurated argillites, and breccias, "which make up the Arvonian group in Pembrokeshire, "occur in great abundance.

"The Pebidian agglomerates at Clegyr Hill are largely "made up of fragments of old rhyolites, like those found in "the ridge at St. David's."

Dr. Hicks considers that the rocks included in the Arvonian group "must have had a volcanic origin."

Dr. Hicks contends that he has evidence "conclusively "showing that there are acid lava flows in the area, which "must be of older date than the Pebidian rocks," and that "this negatives Dr. Geikie's assertions to the contrary, "wherein, he says, that they belong to a much later period "than that of volcanic group, and did not appear to be "superficial lava flows." Respecting the *Pebidian* rocks Dr. Hicks contended "that he had already adduced

" oldest rocks in the district, and that the Cambrian rocks " were largely built up of materials derived from them. The " felstones were alleged to be intrusive rocks, later than the " sedimentary rocks." Dr. Hicks holds " that they are " mostly of pre-Cambrian age, but newer than the granitoid, " and that the majority are old rhyolite or breccias, conse- " quently Dr. Geikie's so-called apophyses cut through the " Dimetian rocks, as fragments are found abundantly in the " Cambrian conglomerates."

Dr. Hicks quoted the Director-General's paragraph, in relation to this part of the conglomerate question, and said, " that Dr. Geikie's assertion seemed to him at the time " to be extremely rash, as he (Dr. Hicks) had often, even " without looking with minuteness, found ample proof that " the Dimetian, Dr. Geikie's so-called granite, as well as " rocks of Arvonian and Pebidian types, had yielded very " much of the material for the Cambrian sediment. Further that the finding of these fragments in the Cambrian conglomerates of St. David's, Dr. Hicks considered, " des- " troyed the very pith of Dr. Geikie's argument."

Dr. Hicks admits " that at present, the evidence as to the " origin of the Dimetian rocks, is not satisfactory, nor, is it " as to the majority of massive gneisses. Whatever may " have been the origin of the Scotch and other gneisses, " he considered it was of like nature, in the case of the " Dimetian, whether a neptunian or a volcanic origin, or a " combination of both be adopted for these rocks, it is an " important fact that these rocks showed peculiarities, when- " ever exposed," which lead Dr. Hicks to " suspect their " age, even where the stratigraphical evidence was not con- " clusive—namely, the peculiar mode of fracture," which condition he considers " was also developed before the Cam- " brian conglomerates were deposited, because it is present " in the fragments contained in these sediments."

Dr. Hicks considers that the term "granitoidite" suggested by Professor Bonney is the best applicable to these rocks as exhibited at St. David's.

One thing is certain—concludes Dr. Hicks on this point—that the Dimetian at St. David's is not, as asserted by Dr. Geikie, a "central boss of eruptive granite with associated "peripheral dykes, elvans, or amorphous intrusions of "quartz-porphry, which has been protruded through the "Cambrian strata. And this is the main point contested."

With regard to the *Arvonian* rocks, Dr. Hicks contends "that they like the Dimetian are older than the Cambrian "conglomerates, because the Cambrian conglomerates con-"tain rolled fragments which cannot be differentiated from "the rocks," and further, "because the conglomerates "repose unconformably upon them, and are almost entirely "built up of materials which could only come from such "rocks. In the lowest Pebidian breccias, fragments of the "peculiar quartz-felsites, indurated argillites, and breccias, "which make up the Arvonian group in Pembrokeshire, "occur in great abundance.

"The Pebidian agglomerates at Clegyr Hill are largely "made up of fragments of old rhyolites, like those found in "the ridge at St. David's."

Dr. Hicks considers that the rocks included in the Arvonian group "must have had a volcanic origin."

Dr. Hicks contends that he has evidence "conclusively "showing that there are acid lava flows in the area, which "must be of older date than the Pebidian rocks," and that "this negatives Dr. Geikie's assertions to the contrary, "wherein, he says, that they belong to a much later period "than that of volcanic group, and did not appear to be "superficial lava flows." Respecting the *Pebidian* rocks Dr. Hicks contended "that he had already adduced

" evidence to show that they were older than the Cambrian " rocks, and that the latter were largely built up of " materials derived from the former. Further, that the " basal conglomerates overlapped the Pebidians unconform- " ably, and were found to be almost at every point in " contact with them." Further, "that the Pebidian rocks " were of older date than the Cambrian, and that they had " formed shore lines, and were much in their present mineral " condition before the Cambrian sediments were deposited." Dr. Hicks contended that " a large proportion of these rocks " are of volcanic origin, and that along with them are some " offering evidence that ordinary marine sediments were " deposited during the period." On the Geological Survey maps the Pebidian rocks are coloured as altered Cambrian or as intrusive greenstones.

Referring to a cliff section, S. E. of Nun's Chapel, which Dr. Hicks said, " Dr. Geikie has endeavoured to explain " away by calling it a case of contemporaneous erosion " accompanying Cambrian conglomerates;" Dr. Hicks contends that " when examined with care it is utterly im- " possible to explain away the facts upon any such " hypothesis." He remarks that " Dr. Geikie states the section " to be in Caer-fai, whereas, in reality it is more than half " a mile west of that creek in Nun's Chapel Bay."

" The Director-General maintained that the volcanic " series are merely the lowest beds of the Cambrian." Dr. Hicks holds, " that there is abundant evidence that they " are truly of pre-Cambrian age, that the Cambrians are " largely made up of fragments and finer materials derived " from them by denudation, and that the basal *Cambrian* " *conglomerates constantly overlap different* members of the " volcanic series."

In conclusion, Dr. Hicks submitted that the evidence he

had laid before the Society clearly showed " that the survey " map of the St. David's district is inaccurate in some of its " essential features, and in many of its petrographical and " stratigraphical details, notwithstanding that Dr. Geikie " maintains that it is in its essential features correct," and that the "officers of the Survey were certainly correct " in regarding the crystalline rocks which they named " as syenite and felstone."

Referring to Dr. Geikie's concluding points, touching the geological history of St. David's district, and reviewing his points thereon, Dr. Hicks says " that the theories worked " out by Dr. Geikie depend entirely for support on the " mistaken supposition that the Dimetian is an intrusive " granite of later date than the whole of the Cambrian " rocks."

Dr. Hicks considers he has " given evidence to show that " there is no foundation for such a supposition, but on the " contrary proved that the Dimetian rocks are much older " than any of the Cambrian rocks, that he had also shown " that the oldest of the Cambrian conglomerates had received " much of their materials from the denudation of the " Dimetian rocks, and that the porcelainites, which Dr. " Geikie supposes were muds or other unchanged sediments, " until after the whole of the Cambrian rocks had been " deposited, were in their present condition in pre-Cambrian " times, as shown by the fragments of them in the con- " glomerates."

In laying before you the preceding lengthy extracts of the views of the various authors upon this question, I am conscious that I have not done that justice to the subject which it deserves, and that there are many points and sections, illustrating both Dr. Geikie's and Dr. Hicks's views, untouched upon. The subject is such a gigantic one,

and the moot point whether or not the central ridge of St. David's be pre-Cambrian, is fraught with such diversity of opinion, backed upon all sides by *ex parte* evidence in such abundance that my difficulty has been to know what to leave unmentioned. I trust, however, the few salient points which I have adduced in these extracts will have conveyed some slight idea of this controversial question.

I may add that a few weeks ago I had the pleasure of hearing Professor Bonney lecture upon "The oldest rocks in England," at the Owens College, in the course of which lectures, illustrated principally by microscopical sections, he spoke about these same rocks, and exhibited microscopic sections of them, and in allusion thereto, considered that the Cambrian conglomerates, before mentioned, contained undoubted fragments of Dr. Hicks's so-called "pre-Cambrian" rocks.

I had the privilege last year of visiting the St. David's locality, and of going over most of the ground mentioned in the preceding extracts. The pleasure that visit afforded me, from a geological point of view, together with the interest which the reading of the various papers had, and since, has afforded me, induced me to think that the introduction of "The question of the Age of the Rocks of St. David's" would be of interest to you.

Having done this, I now beg to leave it for discussion, without having ventured to intrude any opinion of my own.

The CHAIRMAN said he hardly thought that Mr. Burnett need have apologised for his paper, as it showed that he had given laborious and careful attention to the subject.

Mr. MARTIN (hon. secretary) said that, as Mr. Burnett had himself spent some time at St. David's, as well as read a good deal on the subject, it was a pity he had not favoured

the meeting with his own views as to the age of the rocks in question. The ages of certain rocks had not in other places also been satisfactorily settled by the officers of the Geological Survey, who in some parts of the country were doing their work afresh.

Mr. WATTS said: I am in the position, unfortunately, of never having visited St. David's. I am aware, however, of the controversy which has been going on in the geological world for some months past—possibly for a longer period—as to the age of the rocks referred to by Mr. Burnett. It seems to me a case where galloping visits have been made—parties going to the place at one time and another, not seeing the same place nor the same condition of things, and not having even, in all cases, the power of seeing. I am not prepared to discuss the question now, not having read carefully the various papers which have been issued by the Geological Society of London; but I think the Manchester Society is indebted to Mr. Burnett for the care he has taken in preparing the diagrams before us, and giving us an epitome of the papers which have been produced. I regret, however, as Mr. Burnett has been to St. David's, that he did not give us some ideas of his own, and thus make an effort, however humble, to settle this question.

Mr. STIRRUP: I think we must all feel indebted to Mr. Burnett for the trouble he has taken in preparing this paper, but apparently he has only intended to bring before us a summary of the views which have been advanced elsewhere on this much disputed question. He has, no doubt, felt that it would be unwise on his part to venture into a field where there have been given so many hard thrusts. To understand the history of this question one must go very far back. On the one side of the controversy we have the officials of the Geological Survey; on the other side we find leading the van, Dr. Hicks, who as an amateur, living

in the district of St. David's, has made a life-study of these particular rocks. As to his ability as a geologist there is no question, and his opinions are therefore well worthy of attention. Against him we have arrayed such men as the Director-General Dr. Geikie, and his predecessor, Sir A. Ramsay; but I take it that even the officials of the Survey themselves will grant that there is some need of revision in the classification and nomenclature of these oldest rocks in Britain. The map of the Geological Survey, which is before us, is undoubtedly erroneous—that we may well believe, since it dates from 1857. We are all supposed to know a great deal more about the rocks now than we did at that time. The survey, when originally made, was of necessity more superficial than it is now; moreover, in recent years, the study of petrology, or the mineralogical composition and structure of rocks, by the aid of the microscope, has made great strides, and has become of essential service in determining the age of those older rocks where fossils are absent and the stratigraphical position obscure. But the point for us to bear in mind is that in recent years it has become notorious, by the labours of many distinguished workers, and by various means of research, that there is a series of rocks in Britain, previously classed as Cambrian, which are without doubt of pre-Cambrian age. It was formerly thought that we had no rocks in Britain older than the Cambrian, but since the discovery in Canada of a large area of rocks of pre-Cambrian age, to which the name of Laurentian has been given—rocks which are of a highly crystalline and metamorphic character, and undoubtedly underlying the fossiliferous rocks—it has been an object with many geologists in Britain to ascertain whether there were not analogous rocks in this country. Now it appears, as has been stated by Dr. Hicks and others, we have in Pembrokeshire, in the Malvern district, in the Wrekin, in Anglesea, and

in the north-west of Scotland, rocks of the same character as the Laurentian rocks of Canada, to which has been given the name of pre-Cambrian or Archæan. Of what precise age they may be it is no doubt difficult to say. In this case we have no fossils, or only very doubtful ones, to guide us as to age. When you get below the Cambrian series the rocks are, as far as we at present know, unfossiliferous; therefore we have to consider the question of the age of these rocks by an examination of the evidence afforded by their stratigraphical positions, and also, as already stated, by their mineralogical structure. Well, on the latter point there are those who say that you cannot tell the age of a rock from its mineralogical structure alone, as you may have granites and metamorphic rocks of all ages bearing pretty nearly the same appearance. But Professor Bonney, I believe, is of a contrary opinion, and says we are able, by means of the microscope, to tell to a certain extent, whether rocks belong to these older formations or not; and I think Mr. Burnett has not brought Professor Bonney's evidence on the question sufficiently before us, evidence which undoubtedly supports the views of Dr. Hicks, and decides against the Director-General. There is no doubt that the age of all these older rocks is a difficult problem to solve; but out of the discussion which is at present going on we shall ultimately get at something like the truth of the matter. Many eminent geologists have tackled these rocks of St. David's, and have ranged themselves on one side or the other in the controversy. For my part I have never seen them, but have formed an opinion—which, however, may be of no value—from reading the evidence on both sides. No doubt Dr. Hicks has altered his opinion from time to time on some minor points, but on the great question at issue, whether these rocks are of pre-Cambrian age, you may feel quite certain that he is substantially correct. It has been proved

by microscopical examination that portions of these older rocks—call them pre-Cambrian, Archæan, or what you will—are found in the conglomerate rock which is generally regarded as the *base* of the Cambrian series; and if that be so, they must undoubtedly be *pre-Cambrian*, and really bear out what Dr. Hicks has so long maintained, namely, that there are older rocks than the Cambrian at St. David's, and that they are not metamorphosed Cambrians, as has been stated by the officers of the Survey. The terms Pebidian, Arvonian, and Dimetian are terms proposed by Mr. Hicks for these older rocks, but of what precise value these terms may be, whether as distinctive of well-marked groups or the order of succession, is quite a minor matter in the controversy.

Mr. BURNETT said he had not ventured an opinion of his own, for the reason that the more he looked into the question the more conflicting he found the evidence to be. At some future period, if it were desired, he might be prepared to lay his own views before the Society. The fact was, any one going down to the district of St. David's, passing over the ridge from Pen-y-garn to the coast, and examining the exposed rocks, any ordinary student of geology, not specially skilled in the science of petrology, would conclude that those rocks were granite. Their general appearance, in the mass, was decidedly granitic.

DISCUSSION ON MR. STIRRUP'S PAPER ON "COAL AND COAL PLANTS."

Mr. WATTS, referring to the paper read by Mr. Stirrup at a previous meeting, on the subject of Coal and Coal Plants (though not on the circular for discussion to-day), said he should be sorry if so excellent a contribution were passed over in silence. There were one or two passages, however, in the

paper which called for a word of notice: the first was (page 190):—"It teaches us that instead of the different climatal conditions which now obtain, there must then have reigned a uniformity in the diffusion of light and heat over the whole earth, an absence of seasonal changes; such conditions, in fact, of which we have no evidence in succeeding geological epochs." It seemed to him (Mr. Watts) that, in speaking of different climatal conditions, we lost sight of the fact that, during the carboniferous period, there was ample evidence of rain drops on the muddy shores of the estuaries of that distant time; and those rain drops indicated to us storm and sunshine, heat and cold. We had the sun evaporating water from the surface of the ocean, and cold currents of atmospheric air condensing the vapour and causing rain to be precipitated. This showed, at all events, that the temperature was changeable, and not so uniformly equable as Mr. Stirrup and many other geologists supposed. In reference to the amount of land elevated above the surface of the sea, that was a point which required to be examined with very great care; because, the more land, in his opinion, there was elevated above the sea level, the greater area it would present; if the land was flatter there must have been less of it exposed, and the ocean must have extended much further than it does now. There would, therefore, be less area for the production of the material which went to form coal. It appeared to him the case would be this—more land less sea, and less sea more land.

Mr. Tonge said the subject referred to by Mr Watts was one that he was much interested in, but he was hardly prepared to discuss it at that meeting. He suggested, as one reason of the existence of coal in all parts of the globe, that the earth itself in the carboniferous age was much hotter than it is now—that a considerable proportion of the heat stimulating the growth of the carboniferous flora came from

within; but, in addition to this, there must have been a condition of climate much more favourable to the growth of vegetation than prevails at the present day.

The PRESIDENT said the subject was one of considerable interest, and it might be set down for discussion at an early meeting next session.

Mr. STIRRUP said: I did not expect nor am I prepared to discuss in detail my paper at this meeting, but may briefly reply, first, to Mr. Tonge's remark, and I would begin by asking him this question: If in the carboniferous age the earth was far hotter than it is now, owing to its greater internal heat, how would this ensure an uniformity of climate at the tropics and the poles under present physical conditions? The internal heat would, it was presumed, be transmitted pretty equally through the crust of the globe, at the poles, and in the tropical regions, but in the latter case you would have a greater external heat added to the internal—a consideration of things which would altogether deprive us of the same character of vegetation in the tropical regions as we find in the temperate. Then, with regard to the climate, which Mr. Watts did not think could be so equable, seeing that we had evidence of rain. Undoubtedly there must have been rain in the carboniferous age; the solar heat, then as now, would cause vaporization of the waters of the ocean, which must have been condensed again in some form or other to enable the vegetation to grow—heavy dews, as some considered probable, or what was more likely, rain—still there could not have been those divergences of temperature which we have now between the tropics and the temperate and polar regions. It is that difficult point which has to be explained. In the tropics and in the Arctic regions—at the furthest northerly point yet reached—we have a carboniferous flora exactly

rresponding with what we find in the coal deposits of the mperate zone. We know very well that no such vegeta-on can possibly grow in the far north under present nditions, therefore we have to seek for an explanation of hat we find. Of course I throw out these opinions more suggestions for examination and for future inquiry; hat I endeavoured to do in my paper was to bring before ou what I thought would be the most likely explanation of ie very extraordinary facts that we have to deal with in ie carboniferous period. With regard to the land, I marked in my paper that probably there was at that eriod no high mountain land. I would ask Mr. Watts, Where is the evidence of any life, animal or vegetable, habiting mountain regions in the carboniferous age? If iere had been mountains they would most probably have orne a suitable vegetation. But it is a fact acknowledged, believe, by nearly all geologists that there are no fossils ound which indicate high mountain regions; and the haracter of the vegetation that we find, is such as ould seem to typify lowland forests such as those hich we have at the present day on the banks of the mazon and other tropical rivers. Mr. Watts will be ware that most of the high mountain ranges now existing ame into existence during the Tertiary period. The Alps, he Himalayas, and the Andes are all said by geologists to e of comparatively recent date.

Mr. WATTS: My point was that if we had so large a urface of the earth flat, there must have been much more f it covered with water; hence we could not have had a reat area of the coal-bearing material produced as would ppear to be indicated by the paper. That was the point I wanted explaining.

The PRESIDENT said the question was one of so much

interest that it would be well to defer the discussion till a more favourable opportunity.

Mr. STIRRUP said he should be very glad, if it was desired, to supplement his paper by some further observations. There were many points connected with the subject, which, for the sake of brevity, he was obliged to leave out of his paper.

The meeting then concluded.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XVIII. SESSION 1885-6.

ANNUAL MEETING of the Members, held at the Rooms of the Manchester Literary and Philosophical Society, October 6th, 1885.

J. DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Mr. WATTS called the attention of the meeting to the fact that the new museum at Oldham, built by the Corporation of the town, had recently been opened, and that it was the wish of those who were interested in it to furnish it with specimens illustrative of various departments of natural science. He should be glad if he could enlist the co-operation of members of the Manchester Geological Society. If any of them were disposed to contribute specimens, and would entrust them to him, he should be pleased to hand them over to the proper persons.

Mr. MARK STIRRUP, Hon. Sec., read the report of the Council, as follows :—

REPORT OF THE COUNCIL

FOR SESSION 1884-85.

Your Council are pleased at being again in a position to lay a favourable report before you. The work of the Session which has just terminated has been well maintained,

the character of the papers read at the meetings comparing favourably with those of previous years. The financial position of the Society is also in a satisfactory condition, notwithstanding some rather heavy claims upon the year's income.

The usual meetings—one annual and eight ordinary—have been held, and one evening meeting in addition. This latter was held in January, at the Owens College, the intention being that the members should be brought more closely into contact with the valuable geological collection formerly the property of this Society, but which was presented to the College under certain conditions some years since.

Your Council beg to acknowledge the cordial manner in which the authorities of Owens College received the request for permission to hold the evening (January) meeting in the Museum, and to thank them for their co-operation in rendering it successful.

Your Council consider this an appropriate opportunity for reminding members of their privileges as regards entrance to the Museum. The following are the regulations at present in force, as arranged by the College authorities, in accordance with the terms under which the collection was presented to them :—

"The Geological Museum is *open free, and without other restriction* than the entry of the visitor's name in a book kept for the purpose."

To THE PUBLIC, it is open from 10 a.m. to 4 p.m. on Tuesdays, Thursdays and Saturdays, and from 6-30 p.m. to 9 p.m. on Saturday evenings.

To STUDENTS AND MEMBERS OF THIS SOCIETY, it is further open from 10 a.m. to 4 p.m. on Wednesdays and Fridays, and on Friday evenings from 6-30 to 9-30 p.m.

The Museum is closed during the month of August, and from 23rd December to 2nd January inclusive.

With the permission of the College authorities, it is hoped to be able to hold further meetings in the Museum, in order as far as practicable to increase the interest of members and others in the collections.

The new building for the housing of the Geological and Natural History Collections is now well advanced, and it is a pleasant reflection that Manchester, at last, may look forward to no very distant date, when she will have a museum worthy of the district of which it is the centre.

In March an interesting and instructive excursion was made to the works of Messrs. John Brown & Co., Limited, in and near Sheffield. About sixty members and their friends were present. Your Council beg to thank the Directors of the Company for permission to visit their works, and especially to Mr. J. D. Ellis, Managing Director, and Mr. C. E. Rhodes, General Manager of the Collieries, for the arrangements they made for, and the kind reception accorded to, the party.

It is proposed to hold during the ensuing Session two meetings in Wigan, as in the Session just concluded; and the Council look for the co-operation of the members in providing papers and taking part in the discussions thereon.

The introduction of new members must not be lost sight of as a means of advancing the interests of the Society, to replace those lost through various causes.

The Hon. Treasurer's statement of accounts must be considered as satisfactory, remembering that it includes an account for printing of £45 6s. 5d., which should have appeared in last year's balance sheet, but which was not received until too late for admission therein. There is also another exceptional item of £29, for reprinting back numbers which were out of print, and which were often asked for to complete sets of the Transactions.

The expenditure on a new book-case of £12 has to be

provided for in the current Session. It will also be probably necessary to incur a further expenditure for some drawers, cupboards, or other convenient accommodation for storing maps, &c.

The Library Catalogue also requires immediate attention, as many of the additions of recent years have not been entered up, for which some expenditure will be necessary.

Your Council have pleasure in drawing attention to the new position in the building to which your Library has been removed, where the books and maps can be much more conveniently used and consulted than in their former inconvenient quarters.

The members are again reminded that, under the arrangements with the Literary and Philosophical Society, the books and maps belonging to the Geological Society are available daily for consultation in a room provided for the purpose.

Your Council feel that many of those who are interested scientifically and practically in the geology and mining of this district fail to give such support to the Society, the objects of which are geology and mining, as its position and objects merit, and they trust that all will exert themselves to bring the Society before the notice of their friends, and assist in placing it on the soundest and broadest basis possible.

During the Session three deaths occurred among the members, nine have resigned, and the names of five have been removed, in accordance with the twelfth rule of the Society, in consequence of not having paid their subscriptions. Eleven new ordinary members have been elected, the number of members on the list being now 16 honorary, 8 life, and 191 ordinary, or a total of 215 members.

Mr. H. M. Ormerod, Hon. Treasurer, read his financial statement as follows:—

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

1884–5.	Abstract of Receipts.	£	s.	d.
October.—To	Balance brought down, 1884..	84	8	5
,,	Birkenhead Dividends	23	6	6
,,	Lancashire and Yorkshire Dividends	7	15	6
,,	Sale of Transactions	1	16	6
,,	Subscriptions	187	10	0
,,	Arrears.....	31	0	0
,,	Bank Interest.....	0	11	1
		£336	8	0
1885.				
October.—To	Balance brought down.....	£106	10	1

1884–5.	Abstract of Payments.	£	s.	d.
October—By	Library.....	3	2	3
,,	Transactions	128	16	9
,,	Reporters	12	17	0
,,	Circulars, Stationery, &c.....	16	18	6
,,	Postages and Carriage of Parcels	22	5	2
,,	Meetings—Extra Expenses	2	3	3
,,	Collectors' Commission	10	12	6
,,	Rent, &c.	30	0	0
,,	Attendance, Library	2	10	0
,,	Insurance.....	0	12	6
		£229	17	11
,,	Balance carried forward	106	10	1
		£336	8	0

The Investments consist of £600 Four per Cent. Guaranteed Stock of the Birkenhead Railway, and £200 Lancashire and Yorkshire Consolidated Four per Cent. Preference Stock, in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct, 13th October, 1885.

ALFRED PILKINGTON,
JAMES ATHERTON, } Auditors.

HENRY M. ORMEROD, Treasurer.

1st October, 1885.

GENERAL STATEMENT.

	£	s.	d.		£	s.	d.
To Arrears left, 1884, September... ..	59	0	0	By Subscriptions received to September, 1885.....	218	10	0
,, Members as by Account.	211	0	0	,, Members struck off	23	0	0
,, New Members ...	11	0	0	,, Credited to New Life Member	7	0	0
,, New Members, half-year	1	10	0	,, Members dead or discontinued	15	0	0
				,, Arrears remaining.	19	0	0
	£282	10	0		£282	10	0

The resolution for the adoption of the report and accoun[redacted] was then put to the meeting and carried unanimously.

e names of the following gentlemen, recommended by Council for election as officers for the ensuing year, then submitted and unanimously approved by the ng:—

President:

H. M. ORMEROD, F.G.S.

Vice-Presidents:

W. S. BARRETT.
R. T. BURNETT, F.G.S.
GEORGE WILD.
H. A. WOODWARD.

Ex-Officio Vice Presidents:

S HEYWOOD, F.R.S.
ORMEROD, F.G.S.
PH DICKINSON, F.G.S.
EW KNOWLES.
JOHN KNOWLES, M.Inst.C.E.
G. C. GREENWELL, F.G.S.
W. BOYD DAWKINS, F.R.S.
R. CLIFFORD SMITH, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. K. SHUTTLEWORTH, BART.
GEORGE GILROY, M.Inst.C.E.
EDWARD PILKINGTON, J.P.

Hon. Treasurer:

HENRY MERE ORMEROD, F.G.S.

Hon. Secretaries:

PH S. MARTIN, F.G.S. | MARK STIRRUP, F.G.S.

Other Members of the Council:

BURROWS.
DORE D. GRIMKE.
Y HALL.
LES HARDWICK.
HOLLINGWORTH, F.G.S.
LES G. JACKSON.
G LIVESEY.
GEORGE PEACE.
JAMES RADCLIFFE.
JAMES TONGE, F.G.S.
WILLIAM WATTS, F.G.S.
E. LEADER WILLIAMS, M.Inst.C.E.

Hon. Auditors:

FRED PILKINGTON. | JAMES ATHERTON.

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION 1884–5.

1884.

November. The President's Address.

Martin, J. S., F.G.S. "The Action of Coal-Dust in connection with Colliery Explosions."

December. Dawkins, W. Boyd, M.A., F.R.S. "On some Deposits of Apatite near Ottawa, Canada."

De Rance, C.E., Assoc.Inst.C.E., F.G.S. "On the Occurrence of Brine in the Coal Measures, with some Remarks on Filtration.

Martin, J. S., F.G.S. "On an Automatic Safety Lamp."

1885.

January. Burrows, J. S. "On Safety Lamps and various methods of Locking."

Budenberg, A. "Description of Steel Tube Gauge for pressures of 120 lbs. to 10 tons on the square inch."

Dawkins, W. Boyd, M.A., F.R.S. "The Carboniferous Flora. (Given at Owens College.)

Williamson, W. C., LL.D., F.R.S. "The Carboniferous Flora. (Given at Owens College.)

February. Kinahan, G. H., M.R.I.A. "On a possible Genesis of the Canadian Apatite."

Kinahan, G. A. "Notes on Deposits of Apatite near Ottawa."

March. Burrows, J. S. "On Accidents in Mines and their Prevention."

Excursion to Sheffield.

April. Stirrup, Mark, F.G.S. "On Coal and Coal Plants."

May. Burrows, J. S. "Explosions."—Discussion.

June. Burnett, R. T., F.G.S. "On the Question of the Age of the Rocks of St. David's."

NEW ORDINARY MEMBERS.

Ainsworth, John
Aldred, James
Barker, Israel
Bickerton, Charles W.
Campbell, Henry
Elce, George
Hindley, C. E.
Kearsley, William
Shaw, David
Ward, Thomas
Whitehead, John

MEMBERS DECEASED.

Baxter, Henry
Bazley, Sir Thos., Bart.
Maiden, Sampson
Shortrede, Thomas.

MEMBERS RESIGNED, &c.

Bancroft, Henry
Boot, J. Thomas
Crompton, William, in 1882
Dartishire, R. D., F.G.S.
Edmondson, R. H.
Fairley, J. S.
Longbotham, Jonathan
School of Mines, New York
Wild, Joseph

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3, 77-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.

LIST OF MEMBERS.

OCTOBER, 1885.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

ear of ection.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Withins Lane Colliery, Radcliffe.
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Baxenden Collieries, near Accrington.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton. *Hon. Auditor.*
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1885	Barker, Israel, 319, Whit Lane, Pendleton.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool. *Vice-President.*
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1877	Beswick, James, Shakerley Collieries, Tyldesley.
1885	Bickerton, Charles W., Hazel Grove, near Stockport.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Newchurch, near Manchester.
1878	Bradford, The Right Hon. the Earl of, Weston Park, near Shifnal.

Year of Election.	
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 124, Rue Terre Neuve, Brussels.
1877	*Brongniart, Charles*, 8, Rue Guy-de-la-Brosse, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm. Speakman, Summerby, 106, Eccles Old Road, Eccles.
1859	Bryham, William, J.P., Ince Hall, Wigan.
1881	Bryham, Wm., jun., Douglas Bank Colliery, Wigan.
1882	Burnett, R. T., F.G.S., Cresswell Grove, Albert Park, Didsbury. *Vice-President.*
1879	Burns, Thomas, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Yew Tree House, Atherton, near Manchester. *Member of Council.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, Henry, Surveyor, St. Helens.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1882	Cockson, Charles, King Street, Wigan.
1878	Cooke, Charles, Twycross, Atherstone, Leicestershire.
1859	*Coulthart, John Ross, F.R.S., Lit., F.S.A., Scot., Greenlaw Park, Castle Douglas, Kirkcudbrightshire, N.B.
1878	Cowburn, Henry, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1882	Cunliffe, James, Duxbury Park Colliery, Chorley.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C.E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.

Year of Election.	
1862	*Derby, The Right Hon. the Earl of, Knowsley, Liverpool.
1882	Devonport, John, Chamber Collieries, Oldham.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1880	Duncan, William, M.D., Prospect House, Tyldesley.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Old Hall, near Manchester.
1884	Elce, George, Altham Colliery, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskillen, The Right Hon. the Earl of*, F.R.S., Florence Court, Fermanagh.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1873	Garforth, W. E., Colliery Offices, Normanton.
1884	Garside, Sampson, Denton and Houghton Collieries, Denton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Woodlands, Parbold, Wigan, *Past-President.*
1882	Glover, B. B., Haydock, near St. Helens.
1884	Green, George, Tyldesley Colliery, Tyldesley.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1882	Gresley, W., Stukeley, F.G.S., Overseal, Ashby-de-la-Zouch.

Year of Election.	
1863	Greenwell, G. C., F.G.S., Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, jun., Ashton Moss Colliery, Audenshaw, Manchester.
1879	Gregson, Edward, 11, Chapel Street, Preston.
1883	Greensmith, T., Moston Colliery, Failsworth, Manchester.
1880	Grimke, Theodore Drayton, Golborne Hall, Newton-le-Willows. *Member of Council.*
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1879	*Guibal, Theophile*, Professeur d'Exploitation des Mines, Mons, Belgium.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Member of Council.*
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester. *Member of Council.*
1880	Hargreaves, John, Collyhurst Paper Mills, Manchester.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1882	Heathcote, William, Farnworth, near Bolton.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester.
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1883	Hewitt, John R., Mining Engineer, Derby.
1874	Hewlett, W. H., Wigan Coal and Iron Company, Wigan.
1880	Heys, James, Ince Coal and Cannel Company, Ince, Wigan.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, Wigan Coal and Iron Company, Wigan.

Year of Election.	
1885	Hindley, C.E., Clifton Road, Eccles.
1878	Holden, Charles H., Mawdsley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., Haworth's Buildings, Cross Street, Manchester. *Member of Council.*
1884	Howatt, Andrew, 25, Mill Street, Ancoats, Manchester.
1878	Howell, John, Astley, near Manchester.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1880	Hulton, W. W. B., J.P., Hulton Park, near Bolton.
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester. *Member of Council.*
1875	Jackson, J., 5, Wood Street, Bolton.
1880	Jackson, William, 75, Broadway Street, Oldham.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton.
1884	Johnson, M. G., Rainhill, Prescott.
1882	Johnson, William, Abram Colliery, Wigan.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1885	Kearsley, William, 115, Manchester Road, Tyldesley.
1882	Kenney, George, 11, King Street, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Ramilton, S. O. Donegal, Ireland.
1856	Knowles, Andrew, Swinton Hall, Swinton, near Manchester. *Past-President.*
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury. *Past-President.*
1882	Knowles, Israel, Ince, Wigan.
1877	Knowles, Lees, M.A., LL.M., Westwood, Pendlebury.

Year of Election.	
1884	Leach, A. H., Brinsop Hall Colliery, Wigan.
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Member of Council.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 4, Albion Place, Leeds.
1884	Lyon, Edward, Green Heath, Hednesford, S. Staffordshire.
1884	McAdoo, John, Colliery Manager, Hagside, Radcliffe.
1881	McAlpine, G. W., Whinney Hill Colliery, Accrington.
1873	Martin, Joseph S., F.G.S., H.M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1883	Mather, William Penn, Iron Works, Salford.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth. *Past-President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *President and Hon. Treasurer.*
1874	*Owen, Sir Richard*, D.C.L., F.R.S., Sheen Lodge, Richmond Park, London, S.W.
1862	Park, James, Fern Hill, Bury.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grange, Eccles. *Member of Council*
1883	Peace, George Henry, Monton Grange, Eccles.
1877	Peace, Maskell W., F.G.S., Wigan.

Year of Election.	
1881	Pearson, A., Dukinfield Cottage, near Ashton-under-Lyne.
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1881	Pennington, A. S., Wood street, Bolton.
1877	Pennington, Rooke, F.G.S., 14, Acresfield, Bolton.
1882	Percy, C. M., F.G.S., 25, King Street, Wigan.
1878	Perrin, J. Beswick, M.R.C.S.E., F.L.S., Leigh, near Manchester.
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester. *Hon. Auditor.*
1879	Pilkington, Charles, Ashton and Edge Green Collieries, St. Helens.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Astley Deep Pit, Dukinfield. *Member of Council.*
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1882	Rigby, William, Leader's Buildings, King Street, Wigan.
1877	Robins, George J., Ashton, near Newton-le-Willows.
1884	Rogers, William, King street, Wigan.
1884	Roscoe, James, Little Hulton, Bolton.
1882	Sacré, R. A., West Kirby, near Birkenhead.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Darcy Lever Collieries, Bolton

Year of Election.	
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1884	Simpson, W. W., Church, Accrington.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	*Smethurst, William, F.G.S., 1, South John Street, Liverpool.
1838	Smith, G. F., M.A., F.G.S., Grovehurst, Tunbridge Wells.
1881	Smith, John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1881	Squire, J. B., A.Inst.C.E., 1, Sibella Road, Clapham, London, S.W.
1859	Statter, Thomas, Stand Hall, Bury.
1883	Still, Frank Murray, 3, Queen Street, Cheapside, Lond[illegible]
1880	Stirrup, Mark, F.G.S., Richmond Hill, Bowdon. *Secretary.*
1882	Stopford, T. R., Park Hall Colliery, Blackrod, Lancash[illegible]
1882	Storey, Edgar, Leigh, Lancashire.
1881	Taylor, Alfred, Norley Collieries, Wigan.
1880	Teale, William E., Fern Bank, Worsley.
1884	Toman, Daniel, Chamber Colliery, Oldham.
1877	Tomlinson, Thomas, 3 Richmond Terrace, White[illegible] London, S.W.
1873	Tonge, James, F.G.S., Woodbine House, Westhough[illegible]ton, near Bolton. *Member of Council.*
1876	Topping, Walter, Bamfurlong Collieries, near Wigan.
1858	*Trafford, Sir Humphrey de, Bart., Trafford Park, Manchester.

of m.	
'6	Unsworth, John, Scot Lane Collieries, Wigan.
'9	Unsworth, Richard, Mesne Lea Colliery, Worsley.
'7	Waddington, Henry, Burnley Collieries, Burnley.
82	Walker, T. A., Pagefield Iron Works, Wigan.
82	Wall, Henry, 11, King Street, Wigan.
82	Wallwork, Thomas, Colliery Office, Walkden, near Bolton.
'9	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
'9	Warburton, William, High Lane, near Stockport.
85	Ward, Thomas, Northwich.
80	Watts, William, F.G.S., Piethorne, Rochdale. *Member of Council.*
'8	Wells, Samuel B., Mining Engineer to the Bengal Coal Co., Ld., Khooldiah Collieries, Giridih, India.
'7	West, T. E., 65, Werneth Hall Road, Oldham.
84	Whitehead, John, Chorley, Lancashire.
87	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Vice-President.*
80	Williams, E. Leader, M.Inst.C.E., Queen's Chambers, John Dalton street, Manchester. *Member of Council.*
'6	Winstanley, Robert, 28, Deansgate, Manchester.
'6	Woodward, H. A., Clifton, near Manchester. *Vice-President.*
84	Worthington, H., Peel Hall Colliery, Little Hulton, Bolton.
77	Yates, T. M., Anderton Hall Colliery, Blackrod, Chorley.

mbers are requested to communicate to the Hon. Secretaries all s of address, also any corrections or omissions in the list.

PRESENTATIONS TO THE LIBRARY, 1884–85.

Belfast Natural History and Philosophical Society.—Report and Proceedings for Session 1883-84. *From the Society.*

Bristol Naturalists' Society.—Proceedings, Part 3, Vol. IV.—*From the Society.*

Chester Society of Natural Science.—Fourteenth Annual Report, 1884.—*From the Society.*

Chesterfield and Derbyshire Institute of Engineers.—Transactions. Part 4, Vol. X. Contents and Index, Vol. XI., 1882-3, Parts 2-3, Vol. XIII. Parts 1-2, Vol. XIV. *From the Institute.*

Cornwall.—Transactions of the Royal Geological Society of. Part 7, Vol. X. *From the Society.*

Cornwall.—Royal Institution of. Journal, Parts 2-3, Vol. VIII. *From the Council.*

Cornwall.—Mining Association and Institute of Cornwall. Transactions. Part 1, Vol. I. *From the Council.*

Dublin.—Royal Dublin Society.—

Scientific Proceedings. Parts 6-7, Vol. III.; Parts [illegible]-6, Vol. IV.

Scientific Transactions, Vol. I., Series 2, Nos. 20-25; di[illegible]tto, Vol. III., Series 2, Nos. 1-6.

(Part 25: Fossil Fishes of Carboniferous Limestone of G[illegible]reat Britain, by J. W. Davis, F.G.S.

No. 6: Memoirs on the Coleoptera of the Hawaiian Isla[illegible]nds, by Rev. T. Blackburn and Dr. D. Sharp.) *From th Society.*

Edinburgh Geological Society.—Transactions. Part 3, Vol. I[illegible]V. Part 1, Vol. V.—*From the Society.*

Edinburgh Royal Physical Society.—Proceedings, Session 1883[illegible]84. *From the Society.*

Essex Field Club.—Transactions. Part 8, Vol. III. Repor[illegible] of Council for 1883. *From the Club.*

Glasgow Natural History Society.—Proceedings and Transacti[illegible]

Part 3, Vol. V.; Part 1, Vol. I., New Series. *From the Society.*

Glasgow.—Geological Society of.—Transactions. Part. 2, Vol. VII. *From the Society.*

Hertfordshire Natural History Society and Field Club.—Transactions. Parts 1-4, Vol. III. *From the Society.*

Leeds Philosophical and Literary Society.—Annual Report, 1884-5. Description of Megalichthys in Leeds Museum. Pamphlet by Professor L. C. Miall. *From the Society.*

Leicester Literary and Philosophical Society.—Report of Council and Transactions for 1883-4. Inaugural Address, Session 1884-5, by Dr. Shaw. *From the Council.*

Liverpool Geological Society.—Proceedings. Part 1, Vol. V.

Liverpool Science Students' Association.—Session 1883-4. *From the Association.*

London Geological Society.—Quarterly Journal. No. 160, Vol. XL.; Nos. 161-163, Vol. XLI.—*From the Society.*

London Geologists' Association.—Proceedings. Nos. 7-8, Vol. VIII.; Nos. 1-2, Vol. IX. Index to Vol. VIII. *From the Association.*

London Geological Magazine.—Nos. 244-255. *Purchased.*

London.—Institution of Mechanical Engineers.—Proceedings. Nos. 3-4, 1884; Nos. 1-3, 1885. *From the Institution.*

London.—Iron and Steel Institute.—Journal. Nos. 1-2, 1884; No. 1, 1885. *From the Institute.*

London.—Palæontographical Society.—Vol. XXXVIII., 1884. *Purchased.*

London.—Royal Institution of Great Britain.—Proceedings. No. 77, Vol. X., Part 3; No. 78, Vol. XI., Part 1. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 233-4, Vol. XXXVII.; Parts 235-8, Vol. XXXVIII. *From the Society.*

London.—Science Monthly.—Parts 12-14. *From the Editor.*

London.—Society for Psychical Research.—Part 7, 1884. *From the Society.*

Manchester Association of Employers, Foremen, and Draughtsmen. Report of Proceedings and three Pamphlets. *Pamphlet*—The

Turbine as a Water Motor, by Mr. A. Rea. *From the Association.*

Manchester Scientific Students' Association.—Report and Proceedings, 1884. *From the Association.*

Midland Institute of Engineers.—Transactions. Part 74, Vol. IX.; Parts 75-77, Vol. X. *From the Council.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers.—Transactions. Part 4, Vol. XXXIII.; Parts 1-5, Vol. XXXIV. Strata of Northumberland and Durham, as proved by Borings and Sinkings. F. K. 1885. *From the Institute.*

Scotland.—Mining Institute of Scotland.—Transactions. Parts 5-9, Vol. VI.; Parts 1-3, Vol. VII. Catalogue of Library. Rules and List of Members, 1884-5. *From the Council.*

South Wales Institute of Engineers.—Proceedings. Parts 1-3, Vol. XIV. *From the Institute.*

Warwickshire Field Club.—Proceedings, 1884. *From the Club.*

Warwickshire Natural History and Archæological Society. Forty-ninth Annual Report, 1885. *From the Society.*

Yorkshire Geological and Polytechnic Society.—Proceedings. Part 3, Vol. VIII., 1884. *From the Society.*

Campi Phlegrœi.—Observations on the Volcanoes of the Two Sicilies. By Sir William Hamilton. 2 vols., text and plates. *Presented by Henry Wilde, Esq.*

Brighton Corporation Waterworks.—Pamphlet by Edward Easton, C.E. *From W. Whitaker, F G.S.*

On the Area of Chalk as a Source of Water Supply. By W. Whitaker, F.G.S. *Pamphlet from the Author.*

Geological Report on Londonderry and parts of Tyrone and Fermanagh. By J. E. Portlock, F.R.S. *Presented by W. Whitaker, B.A., F.G.S.*

A System of Geology, with a Theory of the Earth. By John Macculloch, M.D. 2 vols. *Presented by W. Whitaker, B.A., F.G.S.*

A Geological Classification of Rocks. By John Macculloch, M.D. *Presented by W. Whitaker, B.A., F.G.S.*

Geology of Cheshire.—Pamphlet by Aubrey Strahan, M.A., F.G.S.

Denudation of North Wales.—Pamphlet by Aubrey Strahan, M.A., F.G.S. *From the Author.*

National Geological Surveys of Europe.—Pamphlet by William Topley, F.G.S. *From the Author.*

Blue Book.—Mining and Mineral Statistics, 1884. *Presented by Joseph Dickinson, F.G.S.*

Blue Book.—Report, with Notes of Evidence taken at the Inquest, Clifton Hall Colliery Explosion, June, 1884, by Mr. Morley. *Presented by Joseph Dickinson, F.G.S.*

Saturated Steam as a Motive Power in Volcanoes. By R. A. Peacock. Pamphlet. *From the Author.*

Treatise on Ore Deposits. By J. A. Phillips. *Purchased.*

Annual Reports, from the Committees.

Cambridge University.—19th Annual Report of Museum and Lecture Rooms Syndicate.

Cambridge.—31st Annual Report of Library Syndicate, June, 1885.

Devon and Exeter Albert Memorial Museum.—15th Annual Report of Committee. April, 1885.

Dundee Free Library. 1884.

Leicester Town Museum.—10th Report. 1884.

Liverpool Free Library and Museum.—32nd Annual Report. 1885.

Manchester.—Owens College.—Calendar. 1884-5 and 1885-6.

Oxford University Museum.—Catalogue, Radcliffe Library. 1884.

Salford Museum, Libraries, and Parks.—36th Annual Report. 1883-4.

Canada and U.S. America.

Canada.—Canadian Institute, Toronto.—Proceedings. Part 3, Vol. II., 1884. Nos. 1-2, Vol. III., 3rd Series.

Canada.—Descriptive Sketch of the Physical Geography and Geology of Canada. By Dr. Selwyn and Dr. Dawson. *From Dr. Selwyn.*

Canada.—Comparative Vocabularies of the Indian Tribes of British Columbia. By W. F. Tolmie and Dr. Dawson.

Canada.—Two Maps of the Dominion of Canada. *From A. R. C. Selwyn, F.R.S., Director of the Survey.*

Canada.—Hamilton Association.—Journal and Proceedings. Part 1, Vol. I.

Canada.—Montreal.—Geological and Natural History Survey. Report of Progress, 1882-83-84. Maps 1 to 6, to accompany the above. Catalogue of Canadian Plants. Part 2. *From A. R. C. Selwyn.*

U.S.A., Columbus.—Report of the Geological Survey of Ohio. Vol. V. Economic Geology. *From Edward Orton, State Geologist.*

U.S.A., Denver.—Colorado Scientific Society.—Proceedings. Vol. I., 1883-4. *From the Society.*

U.S.A., Harvard College.—Annual Report of the Curator of the Museum of Comparative Zoology, 1883-4. *From Alexander Agassiz.*

U.S.A., Harvard College.—Bulletin of the Museum of Comparative Zoology. Vol. VII. No. 2, Vol. XI. No. 1, Vol. XII. Geological Series, Nos. 2 to 8. No. 11, with Index.

U.S.A, Indianopolis.—Department of Geology and Natural History. 14th Annual Report by John Collett, State Geologist. *From the Department.*

U.S.A., Minneapolis.—Geological and Natural History Survey of Minnesota. 1st Annual Report for 1872. 10th Annual Report for 1881. 11th Annual Report for 1882. 12th Annual Report for 1883. *From N. H. Winchell.*

U.S.A., New York.—American Museum of Natural History. Annual Report of Trustees, 1884-5. *From the Committee.*

U.S.A., New York.—American Institute of Mining Engineers. Transactions. Vol. XII., June, 1883, to February, 1884. Vol. XIII., February, 1884, to June, 1885. *From the Institute.*

U.S.A., Philadelphia.—Academy of Natural Sciences. Proceedings. Part 1, 1885. *From the Academy.*

U.S.A., Philadelphia.—Journal of Franklin Institute. Nos. 709-713, Vol. CXIX. Nos. 714-718, Vol. CXX. *From the Institute.*

U.S.A., Smithsonian Institution.—Annual Report for 1882. *From the Board of Regents.*

U.S.A., Washington.—United States Geological Survey.
3rd Annual Report, 1881-82, by J. W. Powell, Director.
Monograph: Vol. III., Geology of the Comstock Lode. Becker.
Atlas to the above. Becker.
Vol. IV., Comstock Mining and Miners, by E. Lord.
Vol. V., Copper-bearing Rocks of Lake Superior, by R. D. Irving.
Vol. VI., Older Mesozoic Flora of Virginia, by W. M. Fontaine.
Vol. VII., Silver Lead Deposits of Eureka, Nevada, by J. S. Curtis. *From the Director of the Survey.*

U.S.A., Washington.—United States Geological Survey.
Bulletin. Nos. 2-6. Mineral Resources of United States, by Williams.
Report of U.S. Geological Survey of Territories, by F. V. Hayden.
Vol. III., Tertiary Vertebrata, Book I., by E. D. Cope.
Vol. VIII., Cretaceous and Tertiary Floras, by L. Lesquereux. *From the Director of the Survey.*

Wyoming Historical and Geological Society.—Proceedings. Part 1, Vol. II.

AUSTRALIA.

Sydney.—Royal Society of New South Wales. Journal and Proceedings. 1883. Vol. XVII.

Victoria.—Gold Fields of. Reports of Mining Registrars. September and December, 1884; March and June, 1885.

Victoria.—Annual Report of Mines and Water Supply for 1884.

FOREIGN.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 2-4, Band XXXVI. Heft 1-2, Band XXXVII. *From the Society.*

Brussels.—Brochure sur la Feuille de Bilsen. By E. Van den Broeck.—*From the Author.*

Buenos Ayres.—Résumenes Generales y Preliminares del Censo Escolar Nacional, 1884. Two copies. Censo Escolar Nacional, 1883-84. Vol. III. Two copies. Estadistica del Comercio y de la Navegacion de la Republica Argentina, 1884. *From the Government.*

Dresden.—Sitzungsberichte der Naturwissenschaftlichen Gesellschaft Isis in Dresden. January to December, 1884. *From the Society.*

Halle, a/S.—Vereins fur Erdkunde. Mittheilungen, 1884. *From the Society.*

Halle, a/S—Kaiserliche. Leop. Carol. Deutschen Akademie der Naturforscher. Band XLV., No. 2. Plagioklasgesteine und Phonolith, by E. Geinitz. Leopoldina. Band XX., 1884. *From the Academy.*

Lausanne: Bulletin de la Société Vaudoise des Sciences Naturelles. No. 91, Vol. XX.; No. 92, Vol. XXI. *From the Society.*

Leipzig.—Sitzungsberichte der Naturforschenden Gesellschaft zu Leipzig, 1884. *From the Society.*

Lille.—Société Géologique du Nord. Annales XI., 1883-4. *From the Society.*

Milan.—Rivista Geologica dei Terreni della Brianza. Pamphlet by G. B. Villa. *From the Author.*

Osnabrück.—Sixth Annual Report des Naturwissenschaftlichen Vereins, 1883-4. *From the Society.*

Paris.—Revue de le Legislation des Mines. Monthly. *Purchased.*

Les Roches, by Ed. Jannetaz. *From the Editor, on behalf of the Author.*

Paléontologie Francaise, par S. Meunier. *From the Editor, on behalf of the Author.*

15 Pamphlets on Fossil Insects, &c. *Presented by the Author, M. Charles Brongniart.*

Pisa.—Atti della Società Toscana di Scienzi Naturali. Memorie. Fasc. 3, Vol. IV. Processi Verbali. Vol. IV. 22 Mars, 1885. *From the Society.*

Roma.—Atti della Reale Accademia dei Lincei. Processi Verbali. Vol. XIV. December, 1884. Transunti. Vol. VIII., Fasc. 16 to last. Fasc. 1-4, Vol. I., 1884-5. Rendiconti. Fasc. 9-20, Vol. I., 1885. Osservazioni Meteorologische, July to December, 1884. Memorie. Vols. 14-17. *From the Academy.*

St. Petersbourg.—Academie Impériale des Sciences. Bulletin. Parts 2-4, Tome XXIX.; Part I., Vol. XXX. Mémoires. Parts 4-13, Tome XXXII. *From the Academy.*

St. Petersbourg.—Institut des Mines. Comité Géologique. Mémoires: Nos. 1-3, Vol. I.; No. 1, Vol. II. Proceedings: Part 1, 1882; 1-7, 1883; 1-10, 1884; and 1-4, 1885. *From the Minister of Domains.*

BOOKS PURCHASED, 1884-5.

Geological Magazine. Nos. 242-255.
Palæontographical Society's Monograph. Vol. XXXVIII. 1884.
Treatise on Ore Deposits. By J. Arthur Phillips.
Revue de la Legislation des Mines. Paris.

Societies with whom the Society Exchanges its Transactions, and Institutions and Journals to whom a Copy is sent Free.

I.—England.

London	British Museum.
	Geological Society.
	Geological Survey.
	Geologists' Association.
	Institute of Mechanical Engineers, Victoria Street, S.W.
	Iron and Steel Institute.
	Royal Institution.
	Royal Society.
	Society for Psychical Research.
Manchester	Association of Employers, Foremen, and Draughtsmen.
	Field Naturalists' Society.
	Free Library.
	Literary and Philosophical Society.
	Owens College.
	Salford Royal Museum and Library.
	Scientific Students' Association.
Barnsley	Midland Institute of Mining Engineers.
Birmingham	Free Library and Museum.

Canada.—Hamilton Association.—Journal and Proceedings. Part 1, Vol. I.

Canada.—Montreal.—Geological and Natural History Survey Report of Progress, 1882-83-84. Maps 1 to 6, to accompany the above. Catalogue of Canadian Plants. Part 2. *From A. R. C. Selwyn.*

U.S.A., Columbus.—Report of the Geological Survey of Ohio Vol. V. Economic Geology. *From Edward Orton, State Geologist.*

U.S.A., Denver.—Colorado Scientific Society.—Proceedings. Vol I., 1883-4. *From the Society.*

U.S.A., Harvard College.—Annual Report of the Curator of the Museum of Comparative Zoology, 1883-4. *From Alexander Agassiz.*

U.S.A., Harvard College.—Bulletin of the Museum of Comparative Zoology. Vol. VII. No. 2, Vol. XI. No. 1, Vol. XII Geological Series, Nos. 2 to 8. No. 11, with Index.

U.S.A, Indianopolis.—Department of Geology and Natural History 14th Annual Report by John Collett, State Geologist. *From the Department.*

U.S.A., Minneapolis.—Geological and Natural History Survey of Minnesota. 1st Annual Report for 1872. 10th Annual Report for 1881. 11th Annual Report for 1882. 12th Annual Report for 1883. *From N. H. Winchell.*

U.S.A., New York.—American Museum of Natural History Annual Report of Trustees, 1884-5. *From the Committee.*

U.S.A., New York.—American Institute of Mining Engineers Transactions. Vol. XII., June, 1883, to February, 1884 Vol. XIII., February, 1884, to June, 1885. *From the Institute.*

U.S.A., Philadelphia.—Academy of Natural Sciences. Proceedings Part 1, 1885. *From the Academy.*

U.S.A., Philadelphia.—Journal of Franklin Institute. Nos. 709 713, Vol. CXIX. Nos. 714-718, Vol. CXX. *From the Institute.*

U.S.A., Smithsonian Institution.—Annual Report for 1882. *From the Board of Regents.*

Royal Physical Society.
.....Geological Society.
Natural History Society.
.....Mining Institute of Scotland.

III.—Ireland.

.....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
.....Natural History Society.

IV.—Australia.

.....Public Library of Victoria.
.....Free Public Library.
Royal Society of New South Wales.
.....John Mackenzie, F.G.S.

V.—Canada.

.....Hamilton Association.
.....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College (Principal, J. W. Dawson, F.G.S.)
.....Canadian Institute.

VI.—United States.

.S. ....Free Library.
U.S....Ohio, Geological Survey of (Professor Edward Orton, State Geologist).
U.S.....Department of Geology and Natural History (John Collett, State Geologist).
*lis, U.S.*E. T. Cox, State Geologist.
, *U.S.*...Professor O. C. Marsh, F.G.S.
, *U.S.*...American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).
.....American Museum of Natural History, Central Park.
hia, U.S...Academy of Natural Sciences.
Franklin Institution.

Dresden.—Sitzungsberichte der Naturwissenschaftlichen Gesellschaft Isis in Dresden. January to December, 1884. *From the Society.*

Halle, a. S.—Vereins für Erdkunde. Mittheilungen, 1884. *From the Society.*

Halle, a. S.—Kaiserliche. Leop. Carol. Deutschen Akademie der Naturforscher. Band XLV., No. 2. Plagioklasgesteine und Phonolith, by E. Geinitz. Leopoldina. Band XX., 1884. *From the Academy.*

Lausanne: Bulletin de la Société Vaudoise des Sciences Naturelles. No. 91. Vol. XX.: No. 92. Vol. XXI. *From the Society.*

Leipzig.—Sitzungsberichte der Naturforschenden Gesellschaft zu Leipzig, 1884. *From the Society.*

Lille.—Société Géologique du Nord. Annales XI., 1883-4. *From the Society.*

Milan.—Rivista Geologica dei Terreni della Brianza. Pamphlet by G. B. Villa. *From the Author.*

Osnabrück.—Sixth Annual Report des Naturwissenschaftlichen Vereins, 1883-4. *From the Society.*

Paris.—Revue de le Legislation des Mines. Monthly. *Purchased.*

Les Roches, by Ed. Jannettaz. *From the Editor, on behalf of the Author.*

Paléontologie Francaise, par S. Meunier. *From the Editor, on behalf of the Author.*

15 Pamphlets on Fossil Insects, &c. *Presented by the Author, M. Charles Brongniart.*

Pisa.—Atti della Società Toscana di Scienzi Naturali. Memorie. Fasc. 3, Vol. IV. Processi Verbali. Vol. IV. 22 Mars, 1885. *From the Society.*

Roma.—Atti della Reale Accademia dei Lincei. Processi Verbali. Vol. XIV. December, 1884. Transunti. Vol. VIII., Fasc. 16 to last. Fasc. 1-4, Vol. I., 1884-5. Rendiconti. Fasc. 9-20, Vol. I., 1885. Osservazioni Meteorologische, July to December, 1884. Memorie. Vols. 14-17. *From the Academy.*

St. Petersbourg.—Academie Impériale des Sciences. Bulletin. Parts 2-4, Tome XXIX.; Part I., Vol. XXX. Mémoires. Parts 4-13, Tome XXXII. *From the Academy.*

The business of the Annual Meeting having been completed, the Meeting resolved itself into an Ordinary one.

The newly-elected President, H. M. Ormerod, F.G.S., took the chair, thanked the members for his election, and promised to fulfil the position to the best of his ability.

NEW MEMBERS.

The following gentlemen were unanimously elected ordinary members of the Society, viz. :—

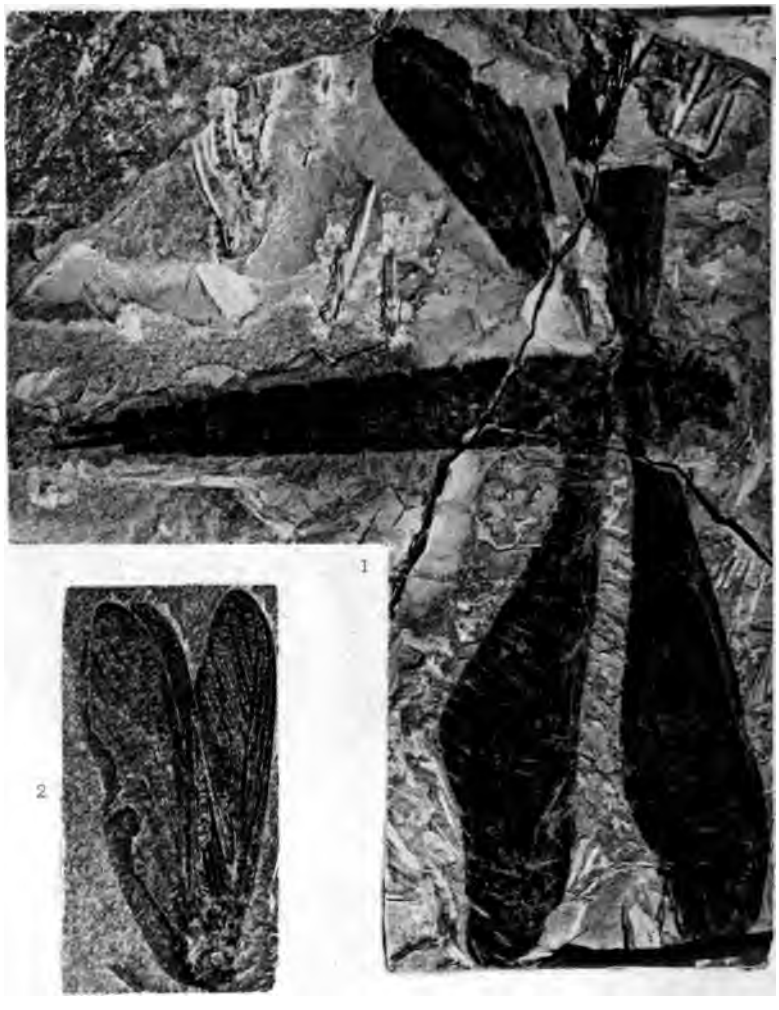
John Turton, jun., one of H.M.'s Inspectors of Mines, Bolton.

Crispin Dugdale, Clough Fold, Rossendale.

THE PALÆOZOIC INSECT FAUNA.

Mr. Mark Stirrup presented a translation which he had made of a communication received from M. Charles Brongniart, of Paris: "On the Fossil Insects of the Primary Group of Rocks: a rapid Survey of the Entomological Fauna of the Palæozoic Systems." In introducing the subject, Mr. Stirrup said that M. Brongniart was some few years ago elected an honorary and corresponding member of the Society, and although he might be unknown personally, he was, no doubt, known to most of the members as the inheritor of a distinguished name in the annals of science. This paper was received from him in the month of July, during the recess. It was upon a subject in which, for some years, the author had taken a deep interest. It was only in recent years that the presence of the remains of insects in the palæozoic rocks had been revealed. In 1867 Mr. Scudder

an American author, described some insects in the Devonian rocks of New Brunswick. That, he (Mr. Stirrup) believed, was the first intimation we had of insects having been found in these primary rocks. Up to the year 1882, 110 specimens only had been found in the whole of the coal strata of the world. These were confined to Germany, America, and France. The first specimens in France were found at Saint Etienne, and the majority of them were comprised in the group Blattidæ, which was represented in our fauna by the familiar cockroach, or black beetle, the remainder, numbering 100 or more insects, belonged to various other orders. The number of species found, had been of recent years continually increasing, principally from the rocks of the United States and of France. Many would ask, Why there has been found such a large number, for instance, in France, and none in our own country? The reason, he believed, was that at Commentry, in France, where such a large number had been discovered, several of the pits were worked in the open daylight—in surface workings; the men were thus able to see readily the fossil impressions in the shale; and, what was, perhaps, more fortunate, there happened to be at the mines at Commentry an engineer, M. Fayol, who took a special interest in looking after these insect remains. In England, no doubt, it would be more difficult to examine the shales of our coal pits, which were often in long galleries under ground. Possibly, however, if insect remains were looked for on the waste heaps lying on the surface, searchers might be rewarded by finding some of those impressions which had been found so plentifully in France. He would also draw attention to the fact, mentioned by the author, that many of the insects described, differed very little from those existing at the present day. It was worthy of notice that, whilst creatures belonging to the higher orders of



1

2

3

1 — WOODWARDIA NIGRA 2 — CALONEURA DENSONII

imal life, such as reptiles, fishes, &c., of which examples d been found in the coal measures, the species then resented were now entirely extinct, while we are able group with living forms, many of the insects which lived the carboniferous period. Mr. Stirrup then read M. ongniart's communication, which was as follows :—

E FOSSIL INSECTS OF THE PRIMARY GROUP OF OCKS: A RAPID SURVEY OF THE ENTOMOLOGICAL FAUNA OF THE PALÆOZOIC SYSTEMS.

By Mr. CHARLES BRONGNIART, of Paris,

norary and Corresponding Member of the Manchester Geological Society.

(*Translated by Mark Stirrup, F.G.S., Hon. Sec.*)

(Received July 17th, 1885.)

The fossil insects of palæozoic times are not yet well own, in consequence of the small number of specimens ich have been discovered in the different carboniferous posits of the globe.

Moreover, these specimens are usually imperfect, and hors generally have had at their disposal only fragments wings, the soft parts of the body having probably rotted ay, leaving no traces upon the schistose rocks.

The rarity and the bad state of preservation of the speci- ns are the principal causes of so few naturalists taking the study of the fossil hexapods.

The important discoveries, however, made since 1878, in mines of Commentry (Allier)—thanks to the devotion the enlightened director of these mines, Mr. Henry yol—have resulted in giving us more exact notions of entomological fauna of the epoch of the coal deposit.

Whilst in Europe and North America there have been

described only about 120 examples, at Commentry, since 1878, 1300 have been met with, of which the greater part is admirably preserved. While up to the time of these discoveries no idea of the form of the body of these coal insects could be given, I am now in a position to make known the external anatomical details of the bodies of these witnesses of bygone ages.

The wings of insects furnish valuable information to aid in their determination, but one must not always rely solely on their form and neuration, for it would often risk the commission of grave errors.

It is necessary, as much as possible, to take into account the characters of the body. Many authors, having had at their command only wings, or fragments of wings, have sometimes been deceived in their determinations. Moreover, it has been too long thought possible that the divisions created to classify living insects could be made to include the insects of the old formations.

It is curious to find how little the insects have changed, to see these creatures, which are reckoned among the most ancient, undergoing modifications of only a secondary order, in coming down to the present time.

Nevertheless, there is more homogeneity among the primary hexapods than this group presents to-day, but there is nothing in that which need astonish us.

The insects which are found in the palæozoic schists belong to types represented at the present day by the Orthoptera, the Neuroptera and the Hemiptera.

Some authors have reported the discovery of Coleoptera; but these so-called Coleoptera are but in reality fossil fruits or Arachnida.

I have, myself, referred to Coleoptera, the perforations found in some fossil woods; but if that were so, the Coleop-

classification from the indications mentioned previously. In fact, it would be compulsory to sunder from one another the Neuroptera (Planipennes and Trichoptera) from the Orthoptera pseudo-Neuroptera, insects, in reality very closely allied. For analogous reasons, one is obliged to abandon the division into Mandibulata and Haustellata groups.

In 1863, Packard proposed to create two series among the insects: the METABOLA and the HETEROMETABOLA. In this latter group he ranges the Coleoptera, Orthoptera, Neuroptera, and the Hemiptera, and bringing into the first group the Hymenoptera, Diptera, and the Lepidoptera.

Samuel H. Scudder had the same idea in this respect as Packard; he created the names of Sternoptena (Metabola of Packard) and of Gastroptena (Heterometabola of Packard.)

But the terms employed by Packard, seemed to him better fitted for general use, and he has adopted them.

Packard and Scudder starting from the principle that the more an Arthropod has the three regions of the body (head, thorax, and abdomen) clearly distinct the one from the other, the more it is raised in organisation, it is among the Hexapoda that this character is most prominent. The Myriopoda, on the contrary, being the most degraded in consequence of the great number of segments of which the body is composed. The higher Crustacea and the Arachnida are intermediate examples, for the head and the thorax are united, and form the Cephalothorax. Among insects the component parts of the thorax are more or less united together among themselves, and those will be the types, whose thoracic segments are the most united, and consequently, whose organs of flight are the most nearly connected, that will be considered as the most perfect.

The METABOLA are precisely the hexapoda which present this perfection in the highest degree. They form unquestionably a more homogeneous section than the HETERO-

METABOLA, and are, moreover, of more recent appearance on the surface of the globe.

Let us then state shortly the principal characters of these two great groups of insects, such as Packard and Scudder have described them :—

METABOLA.	HETEROMETABOLA.
Body clearly divided into three very distinct parts (head thorax, abdomen), the three segments of the thorax closely united together.	Body divided into three parts; the three segments of the thorax are very distinct.
Component pieces of the mouth arranged, as a whole or in part, for suction.	Mouth arranged generally for grinding, rarely for sucking.
Mandibles rarely opposed one to the other.	Mandibles opposed one to the other.
Anterior wings membranaceous and much larger than the posterior, which are sometimes rudimentary.	Anterior wings more or less coriaceous, with very numerous and strong nervures, generally longer and straighter than the posterior wings, or equal to them.
Larva generally soft, not resembling the adult.	Larva most frequently resembling the adult.
Pupa always inactive.	Pupa active or inactive.
Complete metamorphosis	Metamorphosis most frequently incomplete.
Lepidoptera — Diptera — Hymenoptera.	Hemiptera — Neuroptera — Orthoptera

It will be remarked that I have omitted to mention the Coleoptera, which Scudder places among the Heterometabola; but, in my opinion, the Coleoptera form an intermediate group, or are, at least, among the Heterometabola, in course of progression towards the Metabola.

In the primary systems the presence of Coleoptera is, as I have said, very problematical, and the orders, whose existence has been proved, all belong to the great section of the Heterometabola. The classification of Packard and of Scudder is therefore that which agrees the best with the data of palæontology, of embryology, and of morphology.

We proceed now to pass in review the Heterometabola found in the Palæozoic formations, showing the relationships which they offer to the present fauna.

Silurian System.

An insect has been found this year in the sandstone of Jurques (Calvados) analogous to the May Hill sandstone belonging to the Middle Silurian. Some days previously M. Lindström announced the discovery of a scorpion (Palæophoneus nuncius) in the Upper Silurian of the island of Gothland. Almost at the same time a second scorpion was discovered in Scotland in similar deposits.* The impression on the Jurques sandstone consists of a wing whose neuration recalls that of certain Orthoptera of the families of the Acrididæ, Locustidæ, and especially of the Blattidæ.

That which is very remarkable, and which distinguishes this impression from all the wings of living or fossil Blattæ, is the length of the anal nervure and the small width of the axillary field. Pending new discoveries which shall enlighten us concerning the zoological affinities of this fossil, we have placed it in the family of the Blattidæ, under the name of *Palæoblattina Douvillei*.

* M. Brongniart writes to me under date 4th August, 1885, as follows:—"Mr. Scudder has just written to me saying that a Scorpion has recently been found in the United States, in Silurian rocks, analogous to those of Gothland and Scotland, where the two first examples were found."—M. S.

Devonian System.

Several remains of wings have been found in the Devonian schists of New Brunswick; they have been studied with care by Mr. Scudder, who has referred them to the Neuroptera or to the Orthoptera pseudo-Neuroptera.

The estimate of the affinities of these insects is very difficult, and Mr. Hagen has blamed Mr. Scudder for being mistaken in his determinations. Without wishing to impair the importance of the excellent work of Mr. Scudder, we consider that this naturalist has been a little too hasty in his conclusions, and that his determinations are at least a little risky, having regard to the bad state of preservation of his material. Nevertheless, Mr. Hagen has, in our opinion, wandered much further from the truth than Mr. Scudder.

1. *Gerephemera simplex.*

Scudder, who had created the family of the Atocina for this fossil imprint, has brought it into my group of the Protophasmida.

Is it right or wrong? It seems impossible to say, for it appears to me difficult to form a correct opinion from so small a fragment. This wing must have belonged to a large insect; it was about 6 centimètres long. The wing was rather elongated, and the nervures were united by a rather loose reticulation.

2. *Platephemera antiqua.*

It is with reason that Scudder had placed this wing in the the family of the *Ephemeridæ;* Hagen is mistaken in wishing to refer it to an *Odonata.* This wing reminds one much of that of the *Palingenia virgo;* but the fossil is seven times larger than the latter.

3. *Lithentomum Hartii.*

The remains of wing thus called by Scudder is considered by that author as belonging to a neuropterous insect of the

group of the *Sialina*. He creates for it the family of the *Cronicosialina*.

So much trouble appears to me useless, the specimen not being, in my opinion, sufficiently well preserved, to permit the appraising of the characters of this fossil.

4. *Homothetus fossilis*.

The wing that Scudder describes under this name presents characters common to the Neuroptera and the Orthoptera. He creates the family of the HOMOTHETIDÆ for it.

I have been able to compare the figure given by Scudder with some insects from Commentry, and am convinced that this type is near to the *Ephemeridæ* (genus Ephemera and Potamanthus).

5. *Dyscritus vetustus*.

In spite of the smallness of the fragment represented, it ought, in my opinion, to be classed in the same family *(Ephemeridæ* or *Homothetidæ)*.

6. *Xenoneura antiquorum*.

The imprint which the author describes is curious, because it presents at the base of the wing some striæ, which have induced a belief in an apparatus of stridulation.

Scudder having regard to the absence of reticulation between the widely separated nervures, thinks that this insect forms a special and extinct family in the order of the Neuroptera.

I am much of the opinion of Scudder with respect to all these Devonians imprints; but I believe that in the present state of our knowledge it is impossible to be quite certain; we must wait further discoveries. Nevertheless, if Mr. Scudder's opinions are to be accepted, one must believe that the Neuroptera, the Neurorthoptera, and Orthoptera pseudo-Neuroptera were already in existence during the Devonian epoch.

Carboniferous System.

It is in this system that we begin to find a pretty large variety of insects, and, thanks to the fine discoveries made at Commentry, we are able to establish a little order in this very interesting subject of the Palæozoic Hexapoda.

The number of works published on these insects is already considerable, and we owe much to Messrs. Germar, Goldenberg, Geinitz, Sterzel, Van Beneden, Dana, Lacoe, Woodward, Andree, Goss, and, above all, to Scudder, for having studied with patience and perseverance the materials that they have had in their hands.

But, seeing the number, relatively small, of the remains that they have made known, it has been very difficult for them to give a comprehensive view of the entomological fauna of these ancient times.

This task has been for me an easier one, seeing that I have had at my disposal a series of fine and numerous specimens.

I am therefore about to sketch a sort of Prodromus of a Fauna of the Hexapoda of the Coal epoch.

1. *Orthoptera.*

Claus places the Thysanura among the Orthoptera; they are generally considered as being primordial types of insects. No author has described them as occurring in the system with which we are now engaged. Nevertheless they existed as early as the carboniferous period, for 45 specimens have been found at Commentry.

It is difficult to see the number of the joints of the legs, of the palpi and of the antennæ; but these organs can be discerned upon several specimens.

The body is cylindrical, becoming thinner at the posterior part, and terminated by a many articulated filament as long as the body.

The antennæ and the legs are thick and short, the head

appears pretty large. The pro-thorax is very narrow, and the meso-thorax and the meta-thorax are co-equal and much longer than the pro-thorax.

The segments of the abdomen are ten in number and equal in size, the last only is a little longer.

It appears to me that upon one of the specimens, some abdominal plates are seen, as have been observed on the *Machilis*.

The whole of the body (antennæ, legs, thorax, abdomen) is covered with very numerous and very short hairs. The body with the abdominal filament varies in length between 15 and 22 millimètres.

This insect resembles the *Lepisma* and the *Machilis*. It differs from them in several characters, but the principal difference consists in the presence of a single abdominal filament in the fossil species. I shall designate this ancestor of the living Thysanura by the name of *Dasyleptus Lucasi*, dedicating it to Mr. H. Lucas, of the Museum of Paris.

Among the Orthoptera a great number of Blattæ or o PALŒOBLATTARIŒ (Scudder) have been described, and Mr. Scudder has classed them in several groups. He has made a special study of them, therefore I shall not speak of them here.

Goldenberg has named *Fulgorina Klieveri* a wing which must have belonged to a large Blattida ; we shall designate it by the name of *Megablattina Klieveri*.

Another family of Orthoptera was pretty well represented, which I shall call PALÆACRIDIODEA. A first group contains many genera ; the *Oedischia* (mihi), of which the third pair of legs resembles those of living locusts. The *Sthenaropoda*, near allies of the *Oedischia*, but whose legs are thicker and shorter, and less fitted for leaping.

The genus *Protogryllacris* (mihi), represented by an insect called *Corydalis*, then *Gryllacris*, and afterwards *Lithosialis*

Brongniarti by Scudder. The name of *Lithosialis* ought to be changed in order to show that this insect did not resemble the *Sialis*.

A fourth genus, *Paolia* (Scudder), including many species, should come in this first group.

The second group contains three genera:

The *Sthenarocera* (mihi), insects with strong and long antennæ, body short and thick, long legs, and long and narrow wings, recalling somewhat those of the *Pachytylus*.

These insects do not measure less than 11 centimètres from the anterior part of the head to the extremity of the wings, when the latter are folded upon the back.

The *Caloneura* (mihi) (Plate, fig. 2) are near akin to the foregoing; but the legs and the antennæ are more slender, the wings are shorter and not so narrow; the nervures are admirably surrounded by coloured bands.

The *Macrophlebium Hollebeni* of Goldenberg goes into this family for the present.

All these insects may be regarded as the ancestral type of the Orthoptera (Saltatoria) jumpers of the present day.

I shall form the order of the NEURORTHOPTERA, which will include two sub-orders—that of *Neurorthoptera* properly so called, and that of *Palæodictyoptera* (Goldenberg).

The first sub-order will comprise—

1. The family of the *Protophasmida* (mihi), represented by the genera *Protophasma* (mihi) *Lithophasma*, which I create for a wing figured by Goldenberg under the name of *Gryllacris Lithantraca*, and which afterwards Scudder had placed in the genus *Lithosialis;* lastly, the genus *Titanophasma* (mihi), of which *the body only* is known to us, a gigantic body measuring 28 centimètres in length; also the genus *Archegogryllus* (*A. priscus*. Scudder).

2. The family of the *Sthenaropterida*, which includes the *Meganeura Monyi*, a wing measuring 33 centimètres in

length—I had named it *Dictyoneura Monyi;* the *Archæoptilus ingens* (Scudder), and *A. Lucasi* (mihi), wings which must have attained 25 to 30 centimètres in length.

Then the *Megathentomum pustulatum* of Goldenberg will take its place in this family; two insects that Goldenberg had named *Acridites formosus* and *A. carbonatus* will also come into the genus *Megathentomum.*

In this first sub-order of the Neurorthoptera I have placed some insects of large size, whose wings have strong nervures united by a rather loose reticulation, insects which have some likeness to our living Phasmians by the form of the body, but which are much removed from them by the neuration. We must consider the Phasmians as much modified descendants of these ancient types.

The second sub-order has been created by Goldenberg, and has been adopted by other authors. This savant, nevertheless, had elevated it to the rank of an order. It contains a series of insects of rather large size, which seem to have completely disappeared from our present fauna.

The first family, that of the *Stenodictyopterida* is composed of insects which have a thick and short, but broad body, strong legs of moderate length.

But that which rightly characterises them, and makes of them a sufficiently homogeneous group is the reticulation of the wings. The latter are elongate, rather narrow, traversed by rather straight nervures united by a very regular network of great fineness, reminding one a little of the network of the wings of our living Odonates.

This family contains six genera.

1. The genus *Eugereon* of Goldenberg. (*Eugereon Boeckingii*, Gold., *Eugereon Heeri*, mihi) is characterised by a short and thick but broad body; the head is small, the prothorax is scarcely broader than the head, whilst the mesothorax and the metathorax are much broader and longer. The legs are

short and thick, and seem to be spined. As to those special organs which Goldenberg has described near to the mouth of the insect, I have not been able to find them on my specimens which are notwithstanding very well preserved. On the other hand, the abdomen bears at its extremity two recurved appendices.

2. The genus *Scudderia* (mihi) is proposed for an insect whose neuration is different from that of the *Eugereon*, and which is of larger size, the wing measuring nine centimètres in length.

3. I shall name *Megaptilus Blanchardi* that large wing that I previously had supposed must have belonged to the *Titanophasma Fayoli*. Its neuration recalls that of the *Eugereon* and of the *Scudderia*. It must have measured 18 to 20 centimètres in length and five centimètres in breadth. Therefore it has been borne by an insect of respectable size.

4. The *Haplophlebium Barnesii* and *H. longipennis* of Scudder will take their place here.

5. Then will come the *Goldenbergia* (Scudder) and the *Dictyoneura* (Goldenberg).

I place in the genus *Goldenbergia* the following species:—

Termes Heeri .....Goldenberg.
Termes affinis ..... id.
Termes laxus ..... id.
Termes contusa .....Scudder.
Termes longitudinalis ..... id.
Termitidium amissum .....Goldenberg.
Dictyoneura Decheni ..... id.
„ Humboldtiana..... id.
„ anthracophila ..... id.
„ elegans ..... id.
„ elongata ..... id.
„ Smitzii..... id.
„ obsoleta ..... id.
„ sinuosa.....Scudder.

length—I had named it *Dictyoneura Monyi;* the *Archæoptilus ingens* (Scudder), and *A. Lucasi* (mihi), wings which must have attained 25 to 30 centimètres in length.

Then the *Megathentomum pustulatum* of Goldenberg will take its place in this family; two insects that Goldenberg had named *Acridites formosus* and *A. carbonatus* will also come into the genus *Megathentomum.*

In this first sub-order of the Neurorthoptera I have placed some insects of large size, whose wings have strong nervures united by a rather loose reticulation, insects which have some likeness to our living Phasmians by the form of the body, but which are much removed from them by the neuration. We must consider the Phasmians as much modified descendants of these ancient types.

The second sub-order has been created by Goldenberg, and has been adopted by other authors. This savant, nevertheless, had elevated it to the rank of an order. It contains a series of insects of rather large size, which seem to have completely disappeared from our present fauna.

The first family, that of the *Stenodictyopterida* is composed of insects which have a thick and short, but broad body, strong legs of moderate length.

But that which rightly characterises them, and makes of them a sufficiently homogeneous group is the reticulation of the wings. The latter are elongate, rather narrow, traversed by rather straight nervures united by a very regular network of great fineness, reminding one a little of the network of the wings of our living Odonates.

This family contains six genera.

1. The genus *Eugereon* of Goldenberg. (*Eugereon Boeckingii*, Gold., *Eugereon Heeri*, mihi) is characterised by a short and thick but broad body; the head is small, the prothorax is scarcely broader than the head, whilst the mesothorax and the metathorax are much broader and longer. The legs are

short and thick, and seem to be spined. As to those special organs which Goldenberg has described near to the mouth of the insect, I have not been able to find them on my specimens which are notwithstanding very well preserved. On the other hand, the abdomen bears at its extremity two recurved appendices.

2. The genus *Scudderia* (mihi) is proposed for an insect whose neuration is different from that of the *Eugereon*, and which is of larger size, the wing measuring nine centimètres in length.

3. I shall name *Megaptilus Blanchardi* that large wing that I previously had supposed must have belonged to the *Titanophasma Fayoli*. Its neuration recalls that of the *Eugereon* and of the *Scudderia*. It must have measured 18 to 20 centimètres in length and five centimètres in breadth. Therefore it has been borne by an insect of respectable size.

4. The *Haplophlebium Barnesii* and *H. longipennis* of Scudder will take their place here.

5. Then will come the *Goldenbergia* (Scudder) and the *Dictyoneura* (Goldenberg).

I place in the genus *Goldenbergia* the following species:—

Termes Heeri .....Goldenberg.
Termes affinis ..... id.
Termes laxus ..... id.
Termes contusa .....Scudder.
Termes longitudinalis ..... id.
Termitidium amissum .....Goldenberg.
Dictyoneura Decheni ..... id.
„ Humboldtiana..... id.
„ anthracophila ..... id.
„ elegans ..... id.
„ elongata ..... id.
„ Smitzii..... id.
„ obsoleta ..... id.
„ sinuosa.....Scudder.

The genus *Dictyoneura*, Goldenberg will comprehend the *D. Goldenbergi* (mihi), *D. libelluloides* Gold., *D. jucunda* (Scudder).

The body is short and thick, the head is big, the thorax has the three segments nearly equal and much raised, nevertheless the prothorax is narrower. The abdomen measures 45 millimètres in length, and is terminated by two long multiarticulated filaments, and by two recurved hooks; moreover, some foliaceous appendices are observed, borne by the antepenultimate ring. The legs are short, strong, angular, and spined. The wings are not very wide (25 m.m.), and have a very distinctive neuration. The reticulation recalls that of the preceding genera; the wings were traversed by coloured bands.

The second family, that of the HADROBRACHYPODA (mihi), comprises two genera, the *Miamia* (Scudder) *(M. Bronsoni)* and the *Leptoneura* (mihi), *L. Oustaleti*, *L. delicatula*, *L. robusta*, *L. elongata* (mihi).

All these insects have a very distinctive *facies*. They have a little of the appearance of the living Termes, but, nevertheless, they cannot be ranged in the same group. It would not appear to me exaggerated to say that it is an ancestral type of the Termes.

The head is pretty broad, armed with strong mandibles, the antennæ are short, the legs are short and squat, the wings are elongated, a little sickle-shaped, and traversed by fine nervures.

Some wings are still tinted by a rather clear brown pigment.

The third family of these Palæodictyoptera includes some insects absolutely new; I shall designate the family by the name of PLATYPTERIDA.

The wings are broad, generally rounded at their extremity, resembling, morphologically speaking, the wings of the

PROTOPHASMIDA, but differing from them completely by the neuration; the nervures, in fact, are rather separated one from the other, and the wings are coloured by pigments often forming very elegant outlines. The body is less stubbed than that of the preceding insects, and the abdomen is terminated, in one of the types, by two filaments.

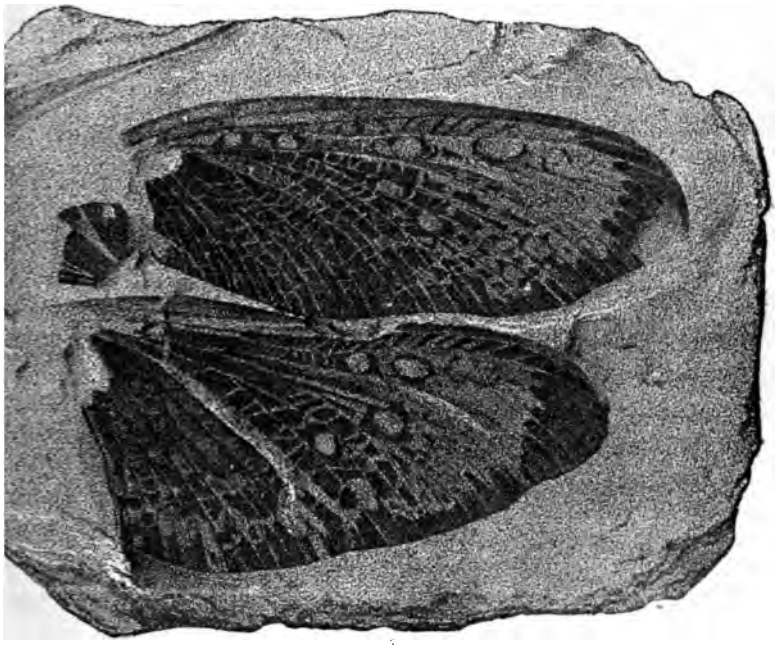
This family will comprise four genera.

1. The *Lamproptilia;* (*L. Grand' Euryi*) *L. priscotincta, L. elegans* (mihi).

2. The *Zeilleria; Z. fusca, Z. formosa, Z. carbonaria* (mihi).

3. The *Spilaptera; S. Packardi, S. venusta, S. libelluloides* (mihi).

4. *Acridites priscus* (Andree).



Insect from Coal Mines of Commentry. *Lamproptilia Grand' Euryi* (Natural Size.)

Afterwards comes a series of insects which may be included in the order of the *Pseudo-Neuroptera;* six families may, in the present state of our knowledge, take their place in this order.

1. The family of the MEGASECOPTERIDA (mihi), (in which I have established eight generic sections) is characterised by insects with a body more or less robust, with a head generally small, with legs of middle size, with an abdomen terminated by two long appendices, which appear to be multi-articulated and hairy, with wings nearly similar to one another, rather elongated and narrowed at their base, showing nervures much separated one from another, and joined again by large nervures, which gives them a very special *facies.*

The abdomen sometimes presents lateral plates which must have served for respiration.

The genera *Protocapnia* (mihi), *Brodia* (*Br. priscotincta*), Scudder, *Trichaptum* (mihi), *Campyloptera* (mihi), will be classed in this group.

The wings of these insects are generally coloured by rather irregularly-disposed spots.

The genus *Sphecoptera* (mihi) comprises insects with very slender wings, very lengthily pedunculated, very narrow and of deep tint, ornamented with little circles deprived of colour, and rather irregularly arranged.

It is here that I believe it possible to place the *Breyeria Borinensis,* described by Mr. Preudhomme de Borre.

The genus *Woodwardia* (mihi) is a very interesting one; it includes three specific types—*W. modesta, W. nigra* (Plate fig. 1), and *W. longicauda.* These two last are remarkably well preserved; the head is rather small, very distinct from the thoracic rings. The prothorax is shorter than the two others order to denote some remarkable specimens that I have received from Commentry.

Rhipidioptera elegans (mihi).

rings. The abdomen, composed of ten rings, is slightly cylindrical, narrower at its extremity, and terminated by two long filaments. The wings are triangular, and, as they are very elongated, they present an obtuse angle nearly in the middle of the wing. The wings are of a deep colour, and present here and there little rounded spots of a brighter shade.

The body of *W. nigra* is 8 centimètres in length, without counting the filaments, which are from 10 to 12 centimètres long. The spread of the fully-extended wings (envergure) is at least 16 centimètres.

It is here that I proceed to place the genus *Corydaloides* (mihi), *C. Scudderi* (Plate, fig. 3), *C. gracilis*, created for some insects of the smallest size, but whose body measures 4 to 5 centimètres in length; the spread of the fully-extended wings is about one décimètre; the body is more stubbed than that of the *Woodwardia*, it is also less cylindrical. The neuration is analagous to that of the preceding genus; the nervures and nervules are nevertheless more abundant, and the wings are not coloured.

But this genus presents a very curious particularity upon which it is well to insist.

Firstly, I will call to your minds in a few words that insects breathe by the aid of tracheæ, whose distribution in the body is variable. Among perfect insects these tracheæ open on the outside by orifices which are called stigmata; these generally breathe the ordinary atmospheric air.

A great number of larvæ, especially those of the Neuroptera and of the Orthoptera, are aquatic, and the organs of respiration are modified. The tracheæ, in place of ending suddenly and presenting openings or *stigmata*, ramify endlessly. Sometimes the extremities of the tracheæ are free, at other times they are united in some kind of foliaceous organs. The insect then breathes the air contained in a state

Afterwards comes a series of insects which may be cluded in the order of the *Pseudo-Neuroptera*; six fam may, in the present state of our knowledge, take their p in this order.

1. The family of the MEGASECOPTERIDA (mihi), (in w I have established eight generic sections) is characterise insects with a body more or less robust, with a head gener small, with legs of middle size, with an abdomen termin by two long appendices, which appear to be multi-articul and hairy, with wings nearly similar to one another, ra elongated and narrowed at their base, showing nervures m separated one from another, and joined again by l nervures, which gives them a very special *facies*.

The abdomen sometimes presents lateral plates w must have served for respiration.

The genera *Protocapnia* (mihi), *Brodia* (*Br. priscotin* Scudder, *Trichaptum* (mihi), *Campyloptera* (mihi), will classed in this group.

The wings of these insects are generally coloured rather irregularly-disposed spots.

The genus *Sphecoptera* (mihi) comprises insects with slender wings, very lengthily pedunculated, very nar and of deep tint, ornamented with little circles deprive colour, and rather irregularly arranged.

It is here that I believe it possible to place the *Brey Borinensis*, described by Mr. Preudhomme de Borre.

The genus *Woodwardia* (mihi) is a very interesting one includes three specific types—*W. modesta*, *W. nigra* (Pl fig. 1), and *W. longicauda*. These two last are remarkably preserved; the head is rather small, very distinct from thoracic rings. The prothorax is shorter than the two ot order to denote some remarkable specimens that I h received from Commentry.

Rhipidioptera elegans (mihi).

h of the living Odonata. There are, nevertheless, some ɜr notable differences.

ɪe third family, that of the HOMOTHETIDA of Scudder, ains some insects of more modest size, more slender ', more sessile wings, and with finer neuration. The ules are also more numerous than with the ASECOPTERIDA.

ı this family will be classed the *Hemeristia occidentalis* dder) the *Pachytylopsis Persenairei* (Preudhomme de e) the *Chrestotes* (*C. lapidea*, Scudder); *C. Danae*, l.; (Synon, *Miamia Danae*, Scud.); *C. Lugauensis* zel; the *Omalia macroptera* (Cœmans and Van Beneden); three new genera from Commentry (genera *Oustaletia*, *hyptilus*, *Diaphanoptera.)*

ɪe three last families of this group include some ancestypes of the Ephemerida, Perlida, and of the Ascalaphus. PROTEPHEMERINA (genus *Homaloneura* (mihi) near to iving *Potamanthus.*) The PROTOPERLIDA (genera, *Promphipnoa* (mihi); *Protokollaria* (mihi); *Pictetia* (mihi); *operla* (mihi).) The PROTOMYRMELEONIDA (genus *Prolaphus* (mihi).)

ɪe order of the HEMIPTERA is represented during the ɔzoic epoch.

ɔ to the present time there have only been met with ı types which we have been able to class in the group e *Homoptera*, these are the ancestors of our Fulgoridæ ɔf our living Cicadellæ.

ıldenberg has named *Fulgorina Ebersi* and *Fulgorina hensis*, some insects very near to our Fulgora.

this same genus I shall place some insects from Comry, *F. Goldendergi* (mihi), *F. ovalis* (mihi), and *F. minor* i).

ıe creation of several generic sections is necessary in

of dissolution in the water, either by the aid of branchial tufts, or by the means of branchial plates.

Among the larvæ of the Ephemera the seven first rings of the abdomen show on each side a foliaceous organ, in which the tracheæ are seen to ramify. The oscillations of these appendices maintain a continuous current around the larvæ; these organs are only obliterated at the time of passage to the state of the sub-imago.

In 1848 Newport made known a pseudo-Neuroptera of the family of the Perlida, the *Pteronarcys regalis*, which presents in the adult state, on the under part of the abdominal rings, some branchial tufts protected by a sort of pocket, and besides which it is provided with stigmata. This insect is amphibious, it can breathe the ordinary atmospheric air and the air which is contained in dissolution in the water.

The *Corydaloides* (mihi) offer in the adult state an analogous disposition of the organs of respiration. Each one of the abdominal rings presents a plate on each side, where one can see very well, even with the naked eye, the branching out of the tracheæ. I have, besides, been able to verify the presence of stigmata. I possess ten examples of imprints of this kind.

It is then permissible to suppose that these insects were amphibious like the *Pteronarcys*.

Like the latter, it presents at the extremity of the abdomen two multiarticulated filaments.

I shall place by the side of these *Megasecopterida* an ancestral type of the Libellulæ; the creation of the PROTODONATA family, and of the genus *Protagrion* seems to me necessary.

Until now a single wing only has been found at Commentry. It measures 10 centimètres in length and two centimètres in breadth.

Its form, its neuration, and its reticulations remind one

The PRESIDENT said: We are all, I am sure, indebted to M. Brongniart for his communication, and to Mr. Stirrup for introducing it. We all know that insects have long ago been found in the Lias, especially in Gloucestershire; but, now, recent discoveries take us back to the Devonian. Are these insect remains, may I ask, found in the shales or in the coal itself?

Mr. STIRRUP, in reply, said that he believed from the information given to him by M. Brongniart that these remains are found in the shales, such as occur in the roofs of our coal mines, where so much of the *débris* of fossil vegetation was found. They are not in any special deposit.

The PRESIDENT: They would appear to be found among the impressions of leaves, on which naturally they would feed.

Mr. DICKINSON: I have great pleasure in moving that a vote of thanks be given to M. Brongniart for his paper, and to Mr. Stirrup for his translation of it. At the same time, it is difficult, and, I think, would be premature, to accept the statements as they have been made. If we assume, as I think the paper states, that all these insects whose remains are found were amphibious, at least at one period of their lives, a great difficulty would be got over. So far as my own experience goes, I have never yet met with a single fossil but what was of some species which, at one period or other of its life, had a water *habitat*. Some few years ago a paper was brought before us, in which it was stated that a fossil spider had been discovered. I replied, rejecting the statement at the time; and I believe that, since then, this so-called spider has proved to be a small lobster. I have seen some of the illustrations that have been handed round; and, clearly to my mind, one at least, represents some creature allied to the lobster; and in all of them there is nothing which may not as

Dictyocicada antiqua (mihi).

Protociccus parvulus and *P. fuscus* (mihi).

Protocixius Fayoli, P. antiquus (mihi).

Mr. Scudder names *Phthanocoris occidentalis* a wing that he considers as belonging to a Hemiptera Heteroptera.

I do not share his opinion, and I find a great analogy in the neuration between this wing and those of the *Pœocera olivacea* (Blanchard) which belong to the Homoptera.

* * * * * *

This paper may be considered as a list, as a general view of the fauna of the primary Hexapoda.

New discoveries will perhaps compel naturalists to multiply genera, but I believe that the general sections already designated will be able to be kept; for all that I have stated is based upon the numerous discoveries made at Commentry during the last eight years.

These discoveries have enabled me to rectify many mistakes made for want of precise data, and for want of fine specimens.

This paper is far from being perfect, but it appears to me necessary, if it only permits of a glance at the riches which have been supplied to me by the mines of Commentry.

Plates are in preparation, and I hope soon to be able to show the figures representing all these curious fossils.

At the moment of going to press I am in receipt of a new memoir from Mr. Scudder, which establishes some new families and genera among the primary hexapods.

In my opinion Mr. Scudder is mistaken in many cases, but we are agreed upon many points. The new genera which he creates demand a close examination, which I reserve for another occasion; but it is curious to note how few types Mr. Scudder has found in America similar to those which have been described in Europe.

allel rods, are jointed, and occasionally divide near the extremities: some are covered with very fine scales, but bear no affinity to the nervures of the wings of insects. The two things are entirely different. I understand from Mr. Ward, of Longton, that such insects are found in the fine shale, and not in the coal; and I have very little doubt, from the nature of the skeletons that are shown in the figures, and from the nervures of the wings, that they are those of insects, but how far aquatic I am not prepared to say. I have seen fossils from Oldham showing insect borings; which leave no doubt in my mind that insects did exist in the carboniferous age.

The PRESIDENT: Are those borings any considerable size?

Mr. WILD: They are only about the sixteenth of an inch in diameter. They are found in a woody sort of nest. They are both longitudinal and transverse in the section, and also pass across from the outside through the bark into the wood.

Mr. WATTS: It would, I am sure, enhance the value of the paper if, when it is printed in the Transactions, some of the photographs which are here shown were published along with it. I do not wonder greatly at the amphibious character of some of the insects described by M. Brongniart, inasmuch as many of our insects at the present day begin life in the water; and it may be that during the carboniferous period, or earlier, more insects began life in the water, and continued to live in it for a longer period than they do now.

The PRESIDENT: It would certainly add to the value of the paper if a selection of these photographs could appear.

Mr. DICKINSON: I think such a paper ought not to be published without giving the reader the means of forming a judgment for himself, the so-called bettles may be little crabs.

Mr. STIRRUP, in replying upon the discussion, said: Mr. Dickinson is so heterodox in his palæontological views, one hardly knows how to answer him. No one, I think, could possibly mistake those objects presented to you in the photographs for anything else but insects, or the wings of insects. The lines and markings show the neuration of undoubted wings, and the position and number of these nervures furnish the distinctive marks of certain insect groups. I do not think that all these insects were aquatic. They belong to numerous orders, some of whose representatives began life in the water, others were amphibious, as shown by M. Brongniart. The Blattidæ occur in warm and humid situations such as we might expect in those forest lands of the coal measure epoch, but their modern representatives certainly are not aquatic. Speaking to the general subject, there cannot be a doubt that insects occurred in profusion in the coal measures. That is the idea we should carry away with us, and I would ask gentlemen connected with coal mines to keep a sharp look-out for fossils of this character. Some of our members will, I hope, have the gratification of bringing such fossils before us, and thereby enable us to dispel the doubts that Mr. Dickinson has expressed.

TRANSACTIONS

OF THE

ANCHESTER GEOLOGICAL SOCIETY.

T XII. VOL. XVIII. SESSION 1885-6.

At the ORDINARY MEETING of the Members of the iety, held on Tuesday, November 10th, 1885, in the rary and Philosophical Society's Rooms, George Street, chester;

The President, H. M. ORMEROD, Esq., F.G.S.,
in the Chair.

---

he PRESIDENT called attention to some markings which d observed recently upon a sandstone flag at Tyldesley. lag came originally from the Edgeworth quarries, and ood out of doors for probably 30 years before it came his notice. It was five feet square, and bore markings iagonal line, with an impression at intervals, which be the trail of some animal, or a stem, and at the end of it there appeared to be footprints which ed out into a long claw in the centre. (A cast arkings was exhibited.) Assuming it to be the or trail of some animal—the nearest approach to to him to be that of a reptilian animal, like that *veton* figured by Mr. W. H. Baily, of the Irish his "Characteristic British Fossils." The flag lower coal measures. The markings occur at rvals of about 3½ inches all across, and there l which turns, quite separate from the mark-

ings, at the top. In one of the spaces there is the impression of a tail, which has swept round on the animal turning.

Mr. Mark Stirrup: Dr. Dawson, of Montreal, has investigated these so-called footprints in similar rocks of Canada, and has published several reports upon them. Some of the markings are extremely curious. The opinion has been expressed that the footprints were probably those of crustaceans, and the trail-like marking as that of the impression of some portion of their bodies when dragged along what has been originally damp mud or sand.

The President: The flag is ripple marked, and in addition to the markings previously described there are casts resembling cockle holes.

Mr. Stirrup: It has evidently come from what has been an old shore, on which, we might naturally expect, a good many marine animals have walked and left their imprints, as we find them on the shores of the present day.

Mr. Dickinson: Do you consider them to be the markings of a lizard?

The President: I look upon the markings as those of some animal which had feet like a lizard, and which had a tail; but I have not seen any picture of any animal that could at all resemble it except that in Mr. Baily's book. That, however, from the account given, is an animal only two or three inches long.

Mr. Dickinson: This which you take to be the production of an animal, say a lizard, I take to be a calamite.

The President: But these markings diverge from those which I call the trail, as if, in the act of turning, the tail of the animal swept over the soft mud, leaving the mark we see.

Mr. Dickinson: No doubt the little aggregations and concretions on that large slab which you have are very curious, but they could not all have been formed by one

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XVIII. SESSION 1885-6.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, November 10th, 1885, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

The President, H. M. ORMEROD, Esq., F.G.S., in the Chair.

The PRESIDENT called attention to some markings which he had observed recently upon a sandstone flag at Tyldesley. The flag came originally from the Edgeworth quarries, and had stood out of doors for probably 30 years before it came under his notice. It was five feet square, and bore markings in a diagonal line, with an impression at intervals, which might be the trail of some animal, or a stem, and at the further end of it there appeared to be footprints which lengthened out into a long claw in the centre. (A cast of the markings was exhibited.) Assuming it to be the footmark or trail of some animal—the nearest approach to it seemed to him to be that of a reptilian animal, like that of *Keraterpeton* figured by Mr. W. H. Baily, of the Irish Survey, in his "Characteristic British Fossils." The flag is from the lower coal measures. The markings occur at regular intervals of about 3½ inches all across, and there is a long trail which turns, quite separate from the mark-

ings, at the top. In one of the spaces there is the impression of a tail, which has swept round on the animal turning.

Mr. MARK STIRRUP: Dr. Dawson, of Montreal, has investigated these so-called footprints in similar rocks of Canada, and has published several reports upon them. Some of the markings are extremely curious. The opinion has been expressed that the footprints were probably those of crustaceans, and the trail-like marking as that of the impression of some portion of their bodies when dragged along what has been originally damp mud or sand.

The PRESIDENT: The flag is ripple marked, and in addition to the markings previously described there are casts resembling cockle holes.

Mr. STIRRUP: It has evidently come from what has been an old shore, on which, we might naturally expect, a good many marine animals have walked and left their imprints, as we find them on the shores of the present day.

Mr. DICKINSON: Do you consider them to be the markings of a lizard?

The PRESIDENT: I look upon the markings as those of some animal which had feet like a lizard, and which had a tail; but I have not seen any picture of any animal that could at all resemble it except that in Mr. Baily's book. That, however, from the account given, is an animal only two or three inches long.

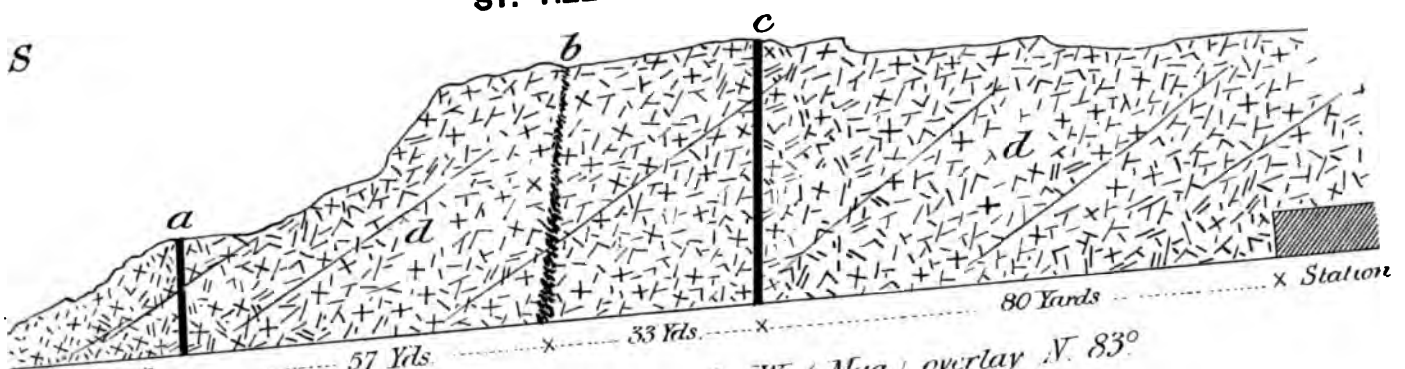
Mr. DICKINSON: This which you take to be the production of an animal, say a lizard, I take to be a calamite.

The PRESIDENT: But these markings diverge from those which I call the trail, as if, in the act of turning, the tail of the animal swept over the soft mud, leaving the mark we see.

Mr. DICKINSON: No doubt the little aggregations and concretions on that large slab which you have are very curious, but they could not all have been formed by one

Trans Man. Geo Soc. Part XII Vol. XVIII. To illustrate Mr Greenwells paper.

SECTION OF ROCKS IN OUTTING NEAR THE EASTERN RAILWAY STATION, ST. HELIER'S, JERSEY.



"a" Basaltic Dyke: direction E & W. (Mag.) overlay N. 83°

"b" Vein of Basalt with Iron Pyrites.

"c" Basaltic Dyke: direction E & W. (Mag.) overlay N. 80°

"d" Granitic Rock.

G C G
Sept 10 1883.

and may probably form a sort of starting point for further inquiry.

The Island is 11 miles in length from east to west, and about 5½ miles in breadth from north to south. St. Helier's the principal town, and harbour of approach from England, is about 100 miles a little to the east of South of Weymouth, and 23 miles nearly due west of St. Germain.

Near to the Dissenters' Cemetery, which lies on the north outskirts of the town, and at 120 yards south of the Cemetery gates, and at the right-hand side (in going up) of the road, which is here in a cutting, the strata are seen to be of light mouse-coloured shales, of which the direction varies from N. 70° W. to N. 88° W., the dip being S. 20° and S. 12° W. respectively, at from 37° to 50°.

Lying about 10 or 12 feet above these beds, and exposed at the other side of the road, are numerous beds of ironstone. The thickness of the bands of ironstone varies from 3 inches to 7 inches. The direction is here N. 45° W., and the dip S. 45° W. at an angle of 45°.

This point is about 100 yards below the Cemetery gates.

At 20 yards further up the road, and on the right-hand side of it, the direction of the strata is N. 34° W., and dip S. 56° W. at 37°, and this is just below the 1 mile-stone (from the Post Office, I presume), and about 70 yards below the Cemetery gates, in going up towards which the direction and dip of the strata continue as last noted.

Towards the top and covering the Hill (Mont á l'Abbaye) is a sort of loose breccia, the composition of which seems to be mainly decomposed granite, there being here and there white lumps which appear to be felspar. This, if in sufficient quantity, might be manufactured into porcelain.

At about 100 yards South East of the Cemetery Gates the strata resemble those lying under the shale and ironstone beds, though probably (unless there is an upthrow fault)

lying very considerably above them. The direction of these beds is here N. 70° W., and dip S. 20° W., at an angle of 35°, but the strata are rather confused.

In a quarry beside the People's Park, which is at the west end of the town and near the sea, stone is worked chiefly for road material. The stone is here a blue whinstone with green lumps and irregular small masses of chlorite, of which the colour is a deep apple-green.

At the railway station of the Eastern Railway (from St. Heliers to Gorey) there is a deep cutting through what appears to resemble a gneissic trap. This is a short distance south of the Post Office.

At 80 yards south of the south end of the station building is a trap dyke, 2 feet 6 inches in thickness, overlying at an angle of 80°. It is seen to the top of the cutting, which is here not less than 100 feet in depth. The trap is a very hard and compact dark whinstone or basalt.

At 32 yards further from the station there is also an appearance of whinstone, with specks of pyrites and crystals of felspar not well defined.

At 57 yards still further from the station there is another whin dyke, direction as before, overlying 83°. In both dykes the overlay is to the north.

The whin of the latter dyke consists of two parts. The northern portion, 1 foot 8 inches thick, is of a purple brown colour, and the southern is 1 foot 8 inches thick, of a dark blue hard flinty whin, like that of the dyke first described.

The rock traversed by the dykes has numerous cracks lying in all directions, but there pervades a certain kind of stratification not entirely irregular.

In passing along the Pier Road south of the railway station, the rock, on which Fort Regent is built, resembles that through which the railway cutting is made. In this there are several cleavages crossing each other at nearly

right angles. The direction of two of these was N. 30° E. and N. 36° E. respectively, and of another N. 40° W.

On the south-west face of the cliff on which the fort stands, and near the engineer's office, is a whin dyke of similar composition to those described above. Its direction is N. 45° E. and it overlies to the S.W. 83½°. Its thickness at the bottom where exposed is 1 foot 6 inches, and it runs out before it reaches the top of the rock.

In passing round along the south shore, by the sea, we find the rock to be mostly of hard blue basalt, with here and there masses of red granite. The change here from basalt to granite is remarkable, and will compare with a similar change at Portrush, in Ireland, from basalt to grey granite.

At Gorey, which is 4½ miles E.N.E., the rocks are similar to those at the railway station cutting; some parts are of a bright green, and some of a purple colour.

At Bouley Bay, on the northern coast and due north of St. Heliers, the rocks are more granitic, and on the road from the table land down to the shore there is a small opening or quarry of *chalk* (?). How it got there is not very easy to discover.

The beach at Bouley Bay is pebbly, and among the pebbles are jaspers and agates in abundance.

Two miles west of Bouley Bay and about a quarter of a mile from the sea are the Mont Mado granite quarries, which are very extensive, and are worked down to a great depth. The stone is chiefly grey granite, like that of Aberdeen, but some of it is red. The grey granite was largely used in the masonry of the Thames Embankment, and enters to a great extent into the buildings constructed in the island.

In St. Peter's Valley, at a place about 3 miles south-west of Mont Mado quarry, and 4 miles north-west of St. Heliers, is a large quarry, where the rocks are of a hard, grey flinty character, regularly stratified. Their direction is

lying very considerably above them. The direction of these beds is here N. 70° W., and dip S. 20° W., at an angle of 35°, but the strata are rather confused.

In a quarry beside the People's Park, which is at the west end of the town and near the sea, stone is worked chiefly for road material. The stone is here a blue whinstone with green lumps and irregular small masses of chlorite, of which the colour is a deep apple-green.

At the railway station of the Eastern Railway (from St. Heliers to Gorey) there is a deep cutting through what appears to resemble a gneissic trap. This is a short distance south of the Post Office.

At 80 yards south of the south end of the station building is a trap dyke, 2 feet 6 inches in thickness, overlying at an angle of 80°. It is seen to the top of the cutting, which is here not less than 100 feet in depth. The trap is a very hard and compact dark whinstone or basalt.

At 32 yards further from the station there is also an appearance of whinstone, with specks of pyrites and crystals of felspar not well defined.

At 57 yards still further from the station there is another whin dyke, direction as before, overlying 83°. In both dykes the overlay is to the north.

The whin of the latter dyke consists of two parts. The northern portion, 1 foot 8 inches thick, is of a purple brown colour, and the southern is 1 foot 8 inches thick, of a dark blue hard flinty whin, like that of the dyke first described.

The rock traversed by the dykes has numerous cracks lying in all directions, but there pervades a certain kind of stratification not entirely irregular.

In passing along the Pier Road south of the railway station, the rock, on which Fort Regent is built, resembles that through which the railway cutting is made. In this there are several cleavages crossing each other at nearly

The south-west part of the island, towards Corbières, consists of granitic rock, and is frequently covered between St. Brelades and St. Aubin's by a peculiar debris difficult to describe. It is a small-grained loose gravelly drift, I should think composed entirely of decomposed rocks of the district. I should say that St. Aubins is four miles due west of St. Heliers; that St. Brelades is 1½ miles west of St. Aubins, and that Cobières is 2 miles west of St. Brelades.

Mr. Dickinson said: I have very much pleasure in moving a vote of thanks to Mr. Greenwell for his paper. It shows that whether we keep upon our own island or extend our observations to the islands near the coast of France, very much the same kind of rocks are to be met with. In an old geological map of Europe, which I bought at Berlin (published by Simon Schropp & Co., 1839), I rather think the geology of these islands is shown. I should like to ask Mr. Greenwell whether he has traced any of the Portrush basalt running into the granite. I have examined those rocks a hundred of times and I have always regarded the basalt of Portrush as entirely distinct from the granite.

Mr. Burnett seconded the vote of thanks, and said: I should like to ask Mr. Greenwell if he observed any traces of unconformability in the stratified rocks towards the trap rocks. Ths Island of Jersey seems to be full of trap rocks as well as true granite. It seems that granite is the true formation of the island, and whether these trap rocks have been intruded sometime in some of the stratified masses we have at present no evidence.

The President: As to that large quarry which appears to be stratified rock, I did not hear what formation you attributed it to. If I understood the paper rightly it was not an igneous rock.

Mr. GREENWELL: I think it depends on what you call igneous. You would not call slate an igneous rock—well, I expect it is about the same age as the slate rocks which have been still more acted upon by the heat of the basalts. I think you may form a pretty fair idea from the specimen exhibited.

In replying to the various questions which had been addressed to him,

Mr. GREENWELL said that all the courses he had given in the paper were taken by the magnetic needle.

Mr. DICKINSON: So, in cases where you gave 75 there would be 20 or 25 degrees to add.

Mr. GREENWELL: There would be about 20 degrees of variation. The other question was about the change at Portrush. The place where that change is seen very distinctly is where you go down the main street at Portrush to the water side, turning to the left hand. There you see the blue basalt change, almost as quickly as it does at Jersey, into grey granite.

Mr. DICKINSON: But there is no granite at Portrush. You have the lias rocks on the shore and the chalk, and one bed of basalt overlying that; and there are different beds of basalt in the neighbourhood.

Mr. GREENWELL: That is perfectly correct. The place where you may see the chalk is between Portrush and the Giant's Causeway: on the right side of the road is a cliff of basalt overlying the chalk. That is evidently a more recent basalt, or trap, than that at Portrush; in the same way as those trap dykes that go through the original whinstone, or whatever you may call it, at Jersey, must have been more recent than it, because they intrude and pass through it; and it is different also in appearance, that trap down at Portrush, from the trap overlying the chalk by the side of the road.

ON WORKING COAL BY LONG-WALL,

With some Remarks on Sudden Outbursts of Inflammable Gas.

By Mr. W. E. Garforth, Mining Engineer.

Experience has shown that no system of working coal can reduce the pressure due to the weight of the superincumbent strata, and this fact becomes more apparent as the strata increase in thickness. Pillars of coal, left as supports whilst the first portion of the seam is removed, have, at shallow depths, remained undisturbed for a long period; but, at an increased depth, have in many instances become so crushed as to render their removal difficult and unprofitable. Such being the case, it must be admitted that the system which necessitates pillars of coal being left for a time, (in some instances until the boundary of the coal-field is reached) cannot in deep mines be worked with the same advantage, as the method which preserves a long face of uncut coal, which, when exposed, can be worked quickly.

It is not the purport of the present paper to compare the systems of the "pillar and stall" of the North, the "work and pillar" system of Lancashire," or the numerous modifications practised in other counties, but rather to submit certain observations on long-wall working and its application to deep mines. To prevent any misunderstanding, the writer would like to state at the outset, that in some mines lying within a few hundred yards of the surface, and in connection with certain natural conditions, there are methods of leaving pillars and getting the coal at two operations, which can be worked to greater advantage than long-wall. This will probably be the case for many years. Several instances could be given where a useless expenditure of money has been made in the attempt to substitute long-wall for pillar working.

The system of leaving pillars has been continued to a greater depth in some collieries situated near large towns, owing to the good demand there has been for small coal, suitable for manufacturing purposes. Had a large percentage of round coal been the chief consideration (which is usually the case), the loss due to the increased proportion of small or crushed coal would have been sooner and more severely felt.

For some years past, in consequence of the mines lying near the surface having become exhausted, there has been a desire to substitute long-wall, even amongst the advocates of pillar working. Errors in the latter system, which were scarcely discernible in mines within a few hundred yards of the surface, have at an increased depth become of serious importance, and created difficulties connected with the under and over-lying strata which formerly were never experienced, and resulted in complaints of tender coal, rotten roof, lifting floor, and sudden outbursts of gas. By leaving an increased size of pillar the system has been maintained for a time, still the complaints referred to may be looked upon as originated by the cause, rather than inherent.

Instances could be given where the same seam, which was profitably and safely worked, by the pillar system, down to a certain depth, and where long-wall could not be so worked, is now, under an increased depth of cover, most advantageously worked on the latter system. The method of working does not merely depend upon the nature of the coal seam, but on the character of the whole superincumbent, and the immediate over and under-lying strata.

As a description of a particular seam, and a statement of facts, will probably lead to the best discussion, the writer proposes in the first instance to lay before you the following particulars, and then to suggest how the rules which have been

found advantageous at 400 to 500 yards will equally apply to mines at 1,000 yards deep.

The mine in question has been worked on the long-wall method from the commencement, but the details have been so materially altered (according as experience gained in working has from time to time suggested), that it may be of interest (at least to some members) to explain the various modifications which preceded and led to the adoption of the present method. It is also considered better to give prominence to some minor matters which have been found advantageous in long-wall working. It is believed such system, more so than pillar working, is essentially dependent on the proper carrying out of certain details, each one perhaps trifling in itself, but in combination tending to make the difference between success and failure.

The seam referred to lies at a depth of 420 yards from the surface, and is 3 feet 7 inches thick of workable coal. The different qualities of the coal, together with the under and over-lying strata, are shown on the accompanying detailed section No. 3. The seam, though slightly undulating, is level over the greater part of the area hitherto worked. The greatest inclination is about 6 degrees.

PLAN No. 1 shows the method which was adopted on reaching the coal: After leaving covering boards adjoining the shaft pillar, stalls, 30 yards wide, were set out on the end of the coal, having steps between varying from four to six yards. This distance was sufficient to allow the timber to be drawn in one place without affecting the adjoining ones, but not so great as to cause a deterioration in the quality of the coal by slabbing similar to "bord" coal. There was, however, a tendency for one stall to lead the others, causing the corners to be crushed, and preventing regular settlements of the overlying strata. In consequence of a number of slips being found sometimes two or three in one yard, a

others only one or two in eight or ten yards, (shewn on the plan by parallel lines) and which extended into the overlying strata, great difficulty was experienced in maintaining the roof. This was owing to the weight being thrown upon the roof as soon as the coal was relieved by the slip.

It was found, after one of these strippings, that when the timber or sprags were drawn, the coal would not fall without the use of gunpowder, although holed to a considerable depth. If holed to the next slip the distance was often so great that when the coal fell the roof fell also. The presence and influence of these slips, which, almost without exception, run parallel in the direction of the bord of the coal, formed the chief cause of the "end on" system being altered to "half end and bord." Had the slips run half end and bord the coal might have been worked plumb end, and a greater proportion of large and cubical coal obtained.

In addition to the difficulty caused by the roof falling as described, gas was often found in the corners of the steps, to prevent which, and to assist the ventilation, packs were carried up the side of the stall.

No. 2 METHOD shows how the coal face was altered from "end" to "half end and bord," so that the slips relieved the overlying strata, and produced such an effect on the coal, that when holed to the same depth as before, it fell as soon as the sprags were drawn, without requiring gunpowder. The roof was also maintained without difficulty, as the lines of face crossed the line of cleavage and the overlying weight was taken by the solid coal as described.

By abolishing the use of gunpowder, which has never since been used in this seam, except in the ripping, the percentage of large coal, though not so cubical, proved to be about the same. Owing to the gateways being kept "end," or at an angle with the line of face, it necessarily

found advantageous at 400 to 500 yards will equally apply to mines at 1,000 yards deep.

The mine in question has been worked on the long-wall method from the commencement, but the details have been so materially altered (according as experience gained in working has from time to time suggested), that it may be of interest (at least to some members) to explain the various modifications which preceded and led to the adoption of the present method. It is also considered better to give prominence to some minor matters which have been found advantageous in long-wall working. It is believed such system, more so than pillar working, is essentially dependent on the proper carrying out of certain details, each one perhaps trifling in itself, but in combination tending to make the difference between success and failure.

The seam referred to lies at a depth of 420 yards from the surface, and is 3 feet 7 inches thick of workable coal. The different qualities of the coal, together with the under and over-lying strata, are shown on the accompanying detailed section No. 3. The seam, though slightly undulating, is level over the greater part of the area hitherto worked. The greatest inclination is about 6 degrees.

PLAN No. 1 shows the method which was adopted on reaching the coal: After leaving covering boards adjoining the shaft pillar, stalls, 30 yards wide, were set out on the end of the coal, having steps between varying from four to six yards. This distance was sufficient to allow the timber to be drawn in one place without affecting the adjoining ones, but not so great as to cause a deterioration in the quality of the coal by slabbing similar to "bord" coal. There was, however, a tendency for one stall to lead the others, causing the corners to be crushed, and preventing regular settlements of the overlying strata. In consequence of a number of slips being found sometimes two or three in one yard, at

When the dirt is thick it becomes crushed, and by taking the weight of the superincumbent strata, there is a greater proportion of large coal produced, and the roof seldom falls. Thick dirt is preferred, for though there is a greater quantity to remove, the holing is easier and the pieces of dirt better for packing. There are several partings in the floor, some of them so smooth or slimy that they materially assist the dirt in crushing out, thus saving the coal from being crushed. The men will often cut an extra 8 or 9 inches into the floor to get the advantage of such partings. For years afterwards it is easy to distinguish, by the increased height of the roadway, where the dirt has been thick.

It will be perceived, from Plan No. 2, that the lines of face are almost straight, the west side being, from actual measurement, nearly one mile in length. For some of the reasons already stated, the straight line of face affords the best lines of fracture, and having no projecting angles to interfere with the regular subsidence of the superincumbent strata, the pressure on the coal face is relieved, and stalls are seldom stopped by weighting.

If certain portions of coal have to be left for the support of barriers, buildings, or for other reasons, then irregular lines of fracture are formed which result in inconvenience, loss, and a liability to sudden outbursts. Several precautions are taken to preserve a straight line of face, the most important being that the "holers" are changed into different stalls. Sometimes only two men are engaged in a stall of 44 yards, whilst in the adjoining one of the same length eight or nine men may be working. This is in consequence of such stalls being behind the proper line of face; and in order to give every assistance to the overhanging weight (when the break takes place), the holing is pushed forward to prevent the weight meeting with unequal resistance. With a view to ascertain how far the breaks extend in

the solid coal, straight-work places have been driven, and the breaks noticed.

Crossgates.—These are carried 27 or 28 yards wide, that is, 17 or 18 yards to finish up to the old goaf, and 10 yards into the solid coal, from which new gates are set out. This width of crossgate allows such a rate of advance that the old stalls are cut off and new ones set out without loss of time. If less than 17 yards is left, it has been proved that the breaks (which run parallel with the old line of face) affect the crossgate by causing frequent falls at the sides. If more than 17 yards, then the breaks due to the crossgate goaf are at right angles, and the road is maintained at less expense. Several different methods have been tried in driving crossgates. In some mines with very bad roofs, and under certain local conditions it is more advantageous to cut them off at 50 yards and have mother-gates, so that in case of a stoppage or fall of roof there is a second road for the conveyance of the coal.

It will be noticed in Drawing No. 2 that the intersection of the two main faces is not in line with the chain road. This is purposely arranged, in order to maintain the principal chain road at the least cost. Experience has shown that when the angular point formed by two faces is too acute, there is a tendency for the roof to blow. The intersection is therefore thrown in the second or third gateway.

Ripping and Packing.—The ripping is usually carried 4 feet high by 6 feet at the top, and tapering to the width of the gateway, say 9 feet. It is carried within 10 to 12 feet of the face, in order to get the full advantage of such dirt under the roof before any settlement takes place. The intervening piece of roof, from the lip of the ripping to the coal face, is left sufficiently strong to prevent any lateral pressure being thrown upon the face.

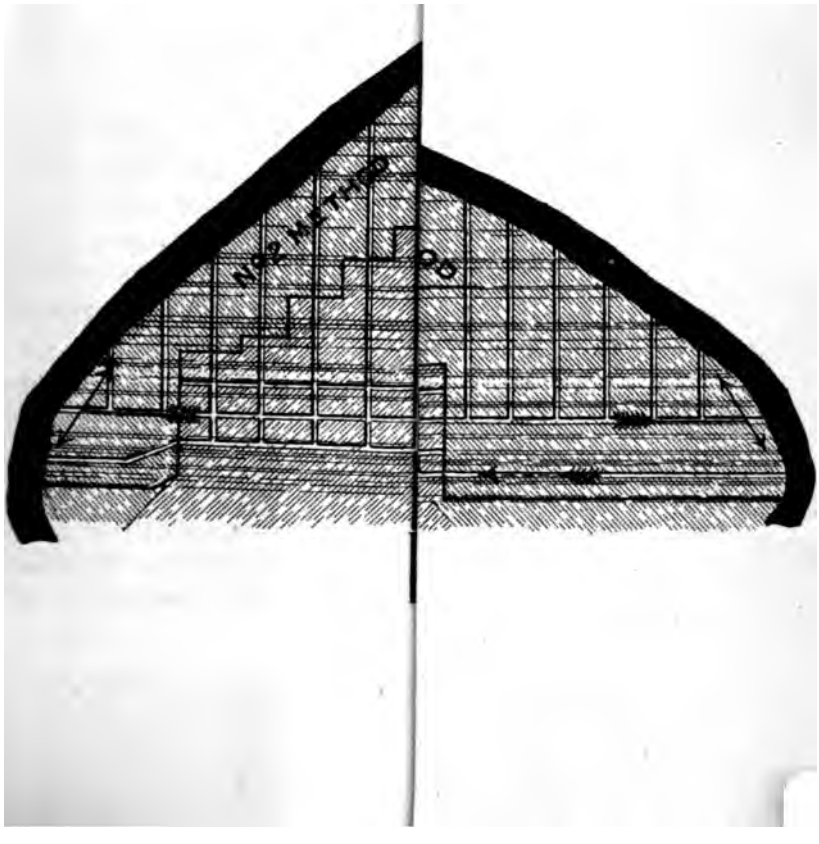
The packs are built with the floor dirt and ripping from

Geo. Soc., Part XII., Vol. XVIII.

ustrate Mr. W. E. Garforth's Paper.

ON V

STEM No. 1, SHEWING "END ON." SHEWING "HALF END AND BOARD.



the solid coal, straight-work places have been driven, and the breaks noticed.

Crossgates.—These are carried 27 or 28 yards wide, that is, 17 or 18 yards to finish up to the old goaf, and 10 yards into the solid coal, from which new gates are set out. This width of crossgate allows such a rate of advance that the old stalls are cut off and new ones set out without loss of time. If less than 17 yards is left, it has been proved that the breaks (which run parallel with the old line of face) affect the crossgate by causing frequent falls at the sides. If more than 17 yards, then the breaks due to the crossgate goaf are at right angles, and the road is maintained at less expense. Several different methods have been tried in driving crossgates. In some mines with very bad roofs, and under certain local conditions it is more advantageous to cut them off at 50 yards and have mother-gates, so that in case of a stoppage or fall of roof there is a second road for the conveyance of the coal.

It will be noticed in Drawing No. 2 that the intersection of the two main faces is not in line with the chain road. This is purposely arranged, in order to maintain the principal chain road at the least cost. Experience has shown that when the angular point formed by two faces is too acute, there is a tendency for the roof to blow. The intersection is therefore thrown in the second or third gateway.

Ripping and Packing.—The ripping is usually carried 4 feet high by 6 feet at the top, and tapering to the width of the gateway, say 9 feet. It is carried within 10 to 12 feet of the face, in order to get the full advantage of such dirt under the roof before any settlement takes place. The intervening piece of roof, from the lip of the ripping to the coal face, is left sufficiently strong to prevent any lateral pressure being thrown upon the face.

The packs are built with the floor dirt and ripping from

When the dirt is thick it becomes crushed, and by taking the weight of the superincumbent strata, there is a greater proportion of large coal produced, and the roof seldom falls. Thick dirt is preferred, for though there is a greater quantity to remove, the holing is easier and the pieces of dirt better for packing. There are several partings in the floor, some of them so smooth or slimy that they materially assist the dirt in crushing out, thus saving the coal from being crushed. The men will often cut an extra 8 or 9 inches into the floor to get the advantage of such partings. For years afterwards it is easy to distinguish, by the increased height of the roadway, where the dirt has been thick.

It will be perceived, from Plan No. 2, that the lines of face are almost straight, the west side being, from actual measurement, nearly one mile in length. For some of the reasons already stated, the straight line of face affords the best lines of fracture, and having no projecting angles to interfere with the regular subsidence of the superincumbent strata, the pressure on the coal face is relieved, and stalls are seldom stopped by weighting.

If certain portions of coal have to be left for the support of barriers, buildings, or for other reasons, then irregular lines of fracture are formed which result in inconvenience, loss, and a liability to sudden outbursts. Several precautions are taken to preserve a straight line of face, the most important being that the "holers" are changed into different stalls. Sometimes only two men are engaged in a stall of 44 yards, whilst in the adjoining one of the same length eight or nine men may be working. This is in consequence of such stalls being behind the proper line of face; and in order to give every assistance to the overhanging weight (when the break takes place), the holing is pushed forward to prevent the weight meeting with unequal resistance. With a view to ascertain how far the breaks extend in

the solid coal, straight-work places have been driven, and the breaks noticed.

Crossgates.—These are carried 27 or 28 yards wide, that is, 17 or 18 yards to finish up to the old goaf, and 10 yards into the solid coal, from which new gates are set out. This width of crossgate allows such a rate of advance that the old stalls are cut off and new ones set out without loss of time. If less than 17 yards is left, it has been proved that the breaks (which run parallel with the old line of face) affect the crossgate by causing frequent falls at the sides. If more than 17 yards, then the breaks due to the crossgate goaf are at right angles, and the road is maintained at less expense. Several different methods have been tried in driving crossgates. In some mines with very bad roofs, and under certain local conditions it is more advantageous to cut them off at 50 yards and have mother-gates, so that in case of a stoppage or fall of roof there is a second road for the conveyance of the coal.

It will be noticed in Drawing No. 2 that the intersection of the two main faces is not in line with the chain road. This is purposely arranged, in order to maintain the principal chain road at the least cost. Experience has shown that when the angular point formed by two faces is too acute, there is a tendency for the roof to blow. The intersection is therefore thrown in the second or third gateway.

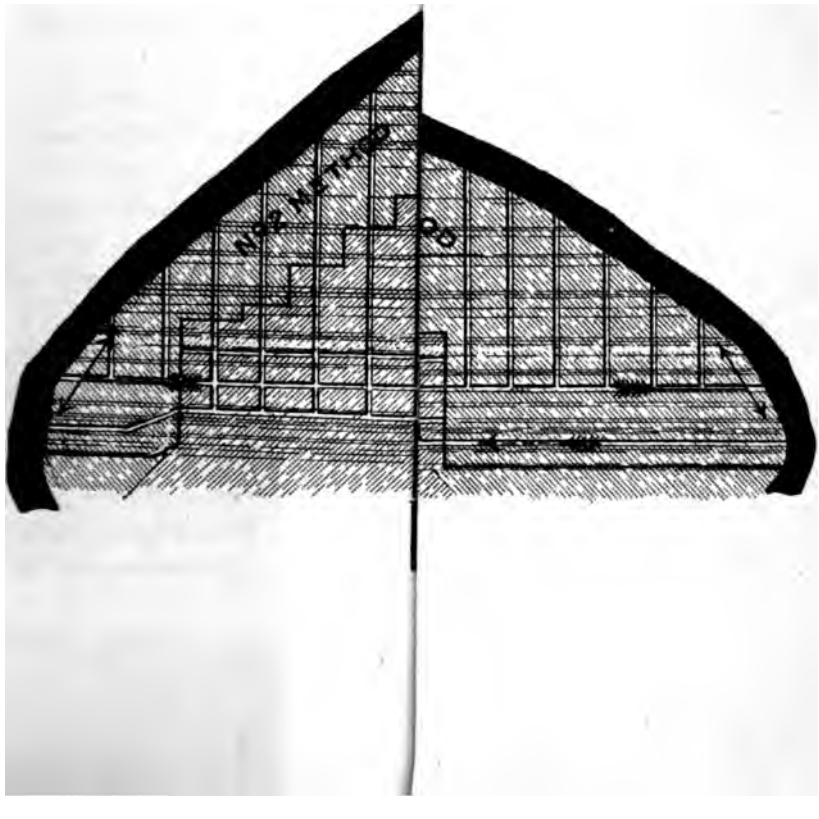
Ripping and Packing.—The ripping is usually carried 4 feet high by 6 feet at the top, and tapering to the width of the gateway, say 9 feet. It is carried within 10 to 12 feet of the face, in order to get the full advantage of such dirt under the roof before any settlement takes place. The intervening piece of roof, from the lip of the ripping to the coal face, is left sufficiently strong to prevent any lateral pressure being thrown upon the face.

The packs are built with the floor dirt and ripping from

. *Geo. Soc., Part XII., Vol. XVIII.*
strate Mr. W. E. Garforth's Paper.

ON V

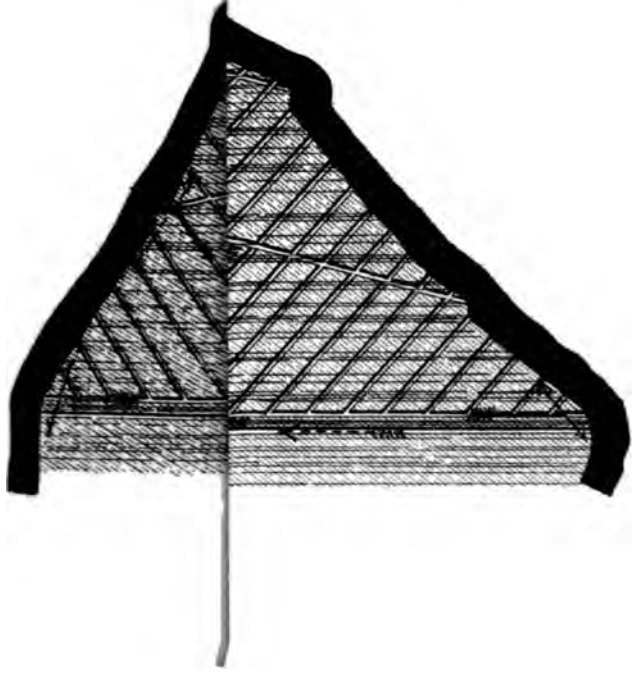
'STEM No. 1, SHEWING "END ON." SHEWING "HALF END AND BOARI



YSTEM No. 3, SHEWING

N. INTAKE.

N. RETURN

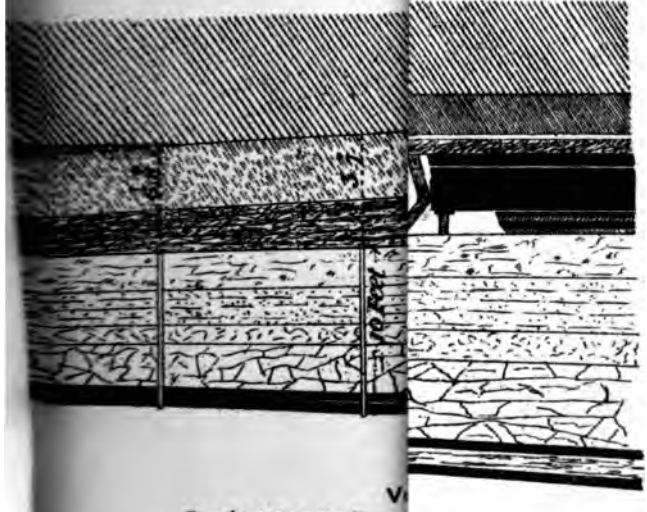


I., Vol. XVIII.

rth's Paper.

ON

LONGI



DETAILED SECTION OF STRATA.

Grey Bind.

Blacks.

HARD COAL.

SOFT COAL

Inferior Coal.

Dirt parting.

Spavin.

Dark Bind.

Strong Blue Bind.

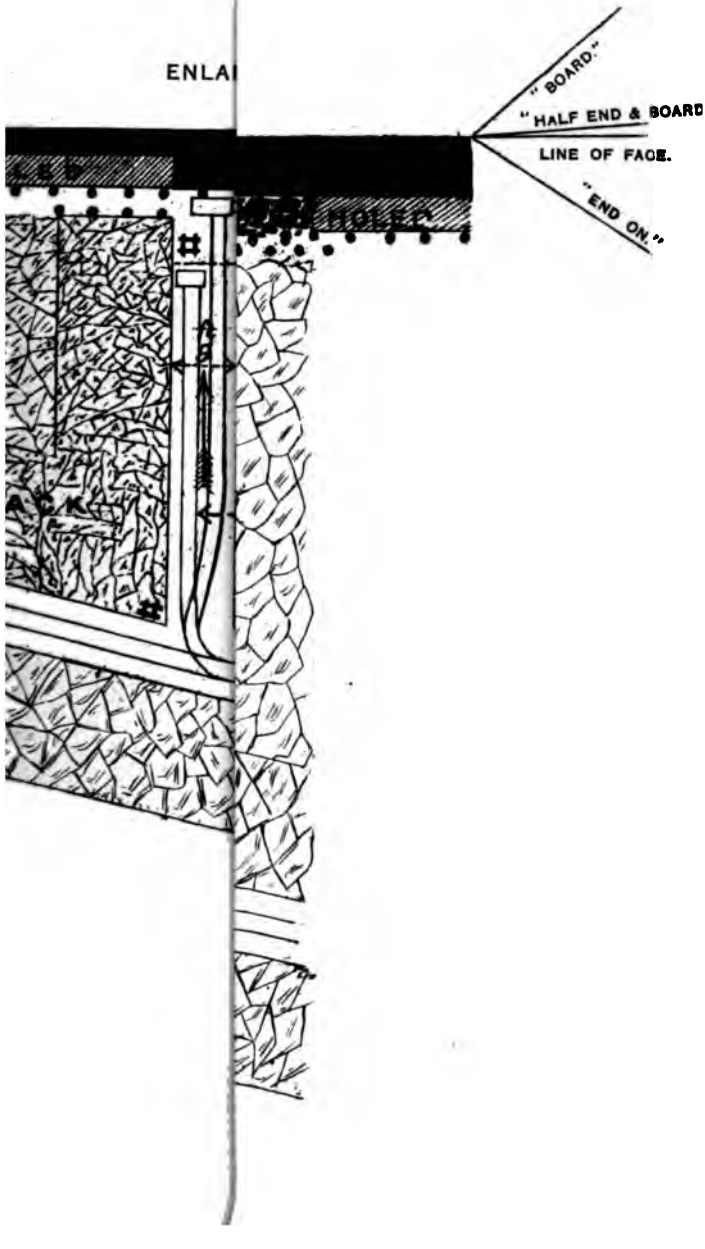
Grey Stone Bind.

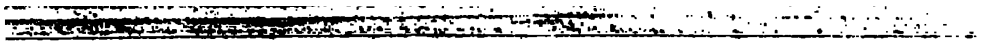
COAL (INFERIOR)

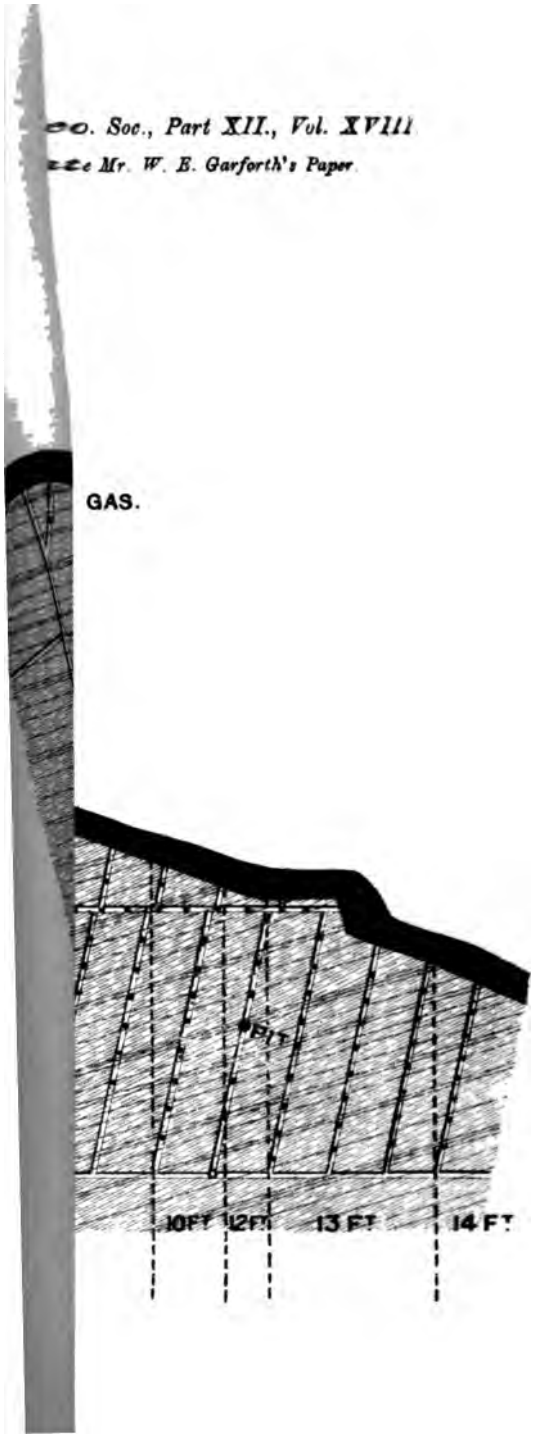
Dirt parting.

COAL (INFERIOR).

Scale (distorted),


ENLA
"BOARD."
"HALF END & BOARD
LINE OF FACE.
"END ON."




GAS.
10FT
12FT
13 FT
14 FT

the gateway. By regularly ripping the roof to within a short distance of the face, the black and gray shale which form it, can be used for facing the packs. Being in larger pieces they are preferable, especially when the holing dirt is thin and makes only small pieces. When the ripping is allowed to get behind, the *debris* has to be carried a further distance, thus entailing extra expense; especially if sent to the surface. As the roof has lowered for want of pack support, the height can never be regained, except at the expense of further ripping. To assist the line of props by preventing the overhanging weight from pressing too much on the coal, besides serving as a species of fulcrum, the packs are carried within about 4 feet of the coal face, or only sufficient space for the corves to pass. One of the main objects in packing is to let the roof settle down as steadily as possible. This can be most effectively done by presenting a large bearing surface, in fact by making the goaf as nearly as possible like its natural state by substituting the pack for the coal. The pack is useless unless it touches the roof, the weight of which otherwise has to be supported principally by the coal face. Far better have packs in contact with the roof and larger wastes (which allow the first portion of the strata to break down) than to have several weak packs.

When the holing dirt is 2 feet thick and the ripping is 4 feet, it admits of the gateway packs being built each 5 yards wide, with two smaller packs intervening. This size is sufficient to support the roof to an extent that the face can be driven about 200 yards before the gateway requires second ripping. The goaf roads give off less gas than those driven in the coal, and when the goaf has properly settled, there is less leakage than in roadways separated by pillars of crushed coal.

The Longitudinal Section, Drawing No. 3, which has been

made from actual measurement, taken at every chain length, represents a gateway about 10 chains long, and shows the effect of the superincumbent weight on the pack from the commencement of the gateway to the face of the coal.

Considering the small amount necessary to maintain the gateways, it will be understood why they are not cut off at less distances than 10 or 11 chains. If the gateway packs are too small there is a greater settlement of the roof: at the same time a narrow pack tends to force up the floor, and still further reduces the headway.

The gateway packs, by being kept to the width named, are sufficient to resist the goaf weight, and in doing this become consolidated. After a little time it is difficult to distinguish between the packs and natural strata.

When a mine is opened out on the long-wall system, serious difficulty and danger have often been experienced when the first weight comes on. Recently the writer has been connected with a seam 4 feet 6 inches thick, where, although the weight was great, not a single place was stopped by weighting in. This result was obtained by packing the goaf as full as possible with all the spare dirt from the roadways, &c. By taking an extra thickness of ripping and building the packs close up to the roof. When the break took place, there was no distance for the roof to fall.

With the exception of the shaft pillar, it is better in most deep mines not to leave any pillar for the support of the main roads; still, if pillars have been left and have unfortunately proved disadvantageous by causing an unequal subsidence, it is better (unless some special local condition arises) to leave the coal pillars, than cause fresh difficulties and a supplementary movement to

take place. It is cheaper to lose the value of the coal (a large proportion of which may be looked upon as small or crushed coal) than to entail extra expense in stoppages, or reduced output, extra timber, &c.

TIMBER.—The coal is spragged by the cockers, as shown in the Sectional Elevation. The cockers are set 6 feet apart, with the cocker poles between, extending in nearly a horizontal direction. The props vary in length from 4 feet 8 inches to 6 feet, according to the undulating floor.

The men are not allowed, unless there is a special reason, (for instance, to assist the lines of fracture) to hole more than 5 feet 6 inches deep, for when the coal (which is of a tender nature) is relieved by the sprags, it breaks off almost like bord coal. In addition to a bad appearance, it is easier broken at the screens, and increases the percentage of slack. The men are cautioned against using the pick on the coal even at a projecting knob, which they are expected to undercut. The props in the second row (see detailed plan of Stall No. 4) are withdrawn as the pack is built.

To prevent the coal face from being crushed, also that there may be no impediment to the superincumbent weight settling on the packs, every care is taken to withdraw the props. Where the dirt is thick and fills the goaf, the props are forced to be drawn and their value saved. In some cases it is more economical to set the timber close together to prevent breakage, and at the same time, to keep the goaf dirt from slipping. It has been found more economical, at the depth of 420 yards, to use props not less than 5½ inches diameter for lengths not exceeding 5 feet, and none less than 6 inches diameter at the small end above 5 feet in length. At each gateway a chock, composed of pieces each 6 inches square and 2 feet long, is set.

The timber-testing machine, which is equal to a force of

500 tons (see Drawing No. 6), has shown that the formulæ given by Tredgold and other authorities for ascertaining the strength of timber is not reliable. Props, of precisely the same size, vary as much as 80 per cent. The following results have been obtained by actual experiment:—

Diameter of Prop.	Length of Prop.	Area of Prop.	Deflection.	Breaking Strain in tons.	Pressure per square inch on Ram.
Inches.	Feet.	Inches.	Inches.	Tons.	Pounds.
6·0	5·00	28·274	1·00	61·50	900
6·0	5·00	28·274	1·25	34·15	500
6·0	5·00	28·274	1·12	43·71	640
6·0	5·33	28·274	1·12	19·00	278
6·0	5·11	28·274	1·25	27·27	398
6·5	5·33	33·183	1·50	45·00	660

The available pressure on the Ram is 7,280 lbs. per square inch.

A chock formed of 24 pieces of elm timber, each piece 2 feet long by 6 inches square, cut perfectly true, gave the following result:—

Pressure per square inch on Ram.	Deflection.	Crushing Strain in Tons.
Pounds.	Inches.	
580	7·00	—
600	8·00	—
620	9.00	—
640	10·37	43
877	——	60

In comparing the strength of a chock with a prop, it may be mentioned that a prop 7¼ inches diameter, 6 feet long, broke at 137 tons.

Chocks are useful in supporting a large area of roof; but they should not be used to screen a bad system of working or to carry a weight, which ought really to be supported by the pack.

VENTILATION.—The ventilation is by furnace, producing about 156,000 cubic feet of air per minute. The several splits of air are shown on Plan No. 2. With the exception of a small quantity required for the furnace and stables, the air is carried direct on to the working face. Hitherto the quantity has been found sufficient to allow the use of open lights by all workmen, except officials.

There are many matters of detail connected with the ventilation, amongst others: Impeding the ventilation by the pack being close up to the face; allowing a wide open space, which the air takes, instead of passing down the gateway; ventilating the wastes, &c., but it would exceed the limits of this paper to refer to them in detail. It may be mentioned in passing that the air can be changed much quicker in long-wall working than by any other method, and this will prove of special advantage in deep mines by reducing the natural temperature of the strata. If long-wall workings are well packed, heavy falls cannot take place in the same way as in pillar working, and though the goafs of the latter may be ventilated, still they are subject to sudden weights.

In connection with this latter point the writer would like to observe that, whilst the velocity of air in the smallest part of a main return will not exceed the velocity safely resisted (in the recent experiments) by some of the most approved safety lamps, still a much greater velocity may be produced in the narrow roadways leading to a goaf by a heavy fall of roof forcing the contents of a large goaf through such narrow passages.

The present area of goaf is approximately 800 acres. No space is left where gas can accumulate, all being crushed close, as shown by the pack in Drawing No. 3, and proved occasionally by roads driven in the goaf.

Sudden Out-bursts of Gas.—From Plan No. 3 it will be noticed that underlying the main coal is a small seam of inferior coal. This latter varies in thickness, but probably gives off more gas in proportion than the main coal. The intervening strata over the greater part of the goaf do not exceed 4 feet. Consequently the superincumbent weight, acting on the pack, has in the past been sufficient to break the strata. The gas from the lower seam has thus been liberated into the upper seam, and become diluted by the main current of fresh air. For many years the deputies' daily reports have shown from 20 to 25 different feeders of gas.

About two years ago, however, in a certain part of the pit, the daily reports of gas almost ceased, but when the feeders of gas were met with they proved stronger. On the assumption that the lower seam produced the same amount of gas as formerly, it was decided to put down a borehole. It was then discovered that the intervening strata had increased in thickness, and the superincumbent weight was not sufficient to cause the same frequent breaks. From the fact that a 3 feet 7 inches seam required over 100,000 feet of air per minute to render the mine safe, it was argued that a seam one-half that thickness should be supplied with at least half that quantity. With a view of carrying out the principle of regularly draining the gas, between 200 and 300 holes have been bored to the underlying seam. The boreholes are put down, as shown on Plan 3, every chain or 22 yards apart; this distance has proved that the last hole affects the previous one. The diameter of the holes is from $2\frac{3}{4}$ to $2\frac{1}{4}$ inches, and the depth varies from 4 to 16 feet to

the underside of the coal. The cost of boring is a shilling per foot deep, or ONE-TENTH OF A PENNY PER TON. Over a large area of the pit the little seam of coal continues within 4 feet of the main coal, otherwise a greater number of holes would have been necessary. Several 4 feet holes have been put down, as it is found better to bring the gas to the most suitable place, than for a break to take place where least expected, and this arrangement has been the means of preventing small fires which formerly took place in the goaf.

As the gas issuing from the boreholes gave off, when lighted, a flame several feet long, a water-guage and very sensitive pressure-guage were arranged to test the pressure of gas. Although the gas fired at the lamp after passing through the U tube, no pressure was exerted. This showed that the gas passed up another hole rather than meet extra resistance. And it was further proved by the last hole affecting the discharge of the previous one.

These facts suggested the experiment that one of the boreholes should be filled with some cheap mineral oil, to further prove the existence of a cavity. After the borehole was filled, and part of the oil had disappeared, a small pit, 4 feet diameter, was sunk. On reaching the coal it was discovered that the black shale forming the roof was stained with oil from the centre to the outside of the pit, a distance of about 2 feet.

A section of the floor of the gateway has been carefully made with the level and staff, and shows, as might be expected, that the greatest upheaval, (or weak point, as it may be termed,) is almost midway between the most consolidated part of the pack and the coal face.

Assuming the distance from the consolidated pack to the coal face to be 40 yards, then that distance multiplied by a certain length of face, say 121 yards, equals an acre. This area, by an average thickness of half an inch, equals 1,815

cubic feet. If this cavity were filled with inflammable gas, at atmospheric pressure, it would require about 36,300 feet of fresh air to render it harmless. The gas would, however, be under a certain amount of pressure, consequently would require a greater quantity of air to dilute it. If five atmospheres are assumed, the same sized cavity would require about 181,500 cubic feet, or at ten atmospheres 363,000 cubic feet. If at the same pressure Mr. Lindsay Wood* obtained in a borehole 32 feet in the solid coal, say 461 lbs., the air necessary to dilute one acre of gas half an inch thick, would be about 1,000,000 cubic feet. If these figures are multiplied to correspond to an opening one or two inches thick, or to an area of 10 acres (or, say, 10,000,000 cubic feet), it may be imagined that a cavity or cavities may be formed of sufficient capacity to contain the immense volumes of gas which have been suddenly given off and met with in actual experience.

Many instances could be given, especially in South Yorkshire, of the large volumes of gas discharged by sudden outbursts, sufficient to foul the largest quantities of fresh air in the best ventilated collieries. From the description given in the Midland Institute Transactions, Vol. IX., page 73, a current of air equal to 40,000 cubic feet per minute was fouled for several consecutive days. Except in the case of faults, no structural difference has been shown to coincide with the locality of an outburst. Where a fault exists, different conditions will naturally arise.

To form a theory based on the foregoing facts. It would seem, that as the main or upper seam of coal is worked out, the intervening strata may be looked upon as an inverted bridge or girder, encased at one end by the solid coal, and at the other by the consolidated pack, having the

* A Paper read before the North of England Institute of Mining Engineers, June 19th, 1880.

least resistance in the middle, where the pack has not been much compressed. As the distance from the coal face to the solidified pack increases, the girder (the strength of which is inversely as the length) becomes weaker, the consequent deflection (or curvature of the intervening strata) forms a cavity which becomes filled with gas as it gradually exudes from the coal, the total load increases until the breaking strain is reached, when the strata becomes fractured, and the pent up gas (probably the accumulation of weeks) escapes at great pressure. What the pressure may be will probably afford arguments for discussion. There are reasons for believing it will exceed at the moment of fracture the pressure stated by Mr. Lindsay Wood. With reference to other theories which have been advanced, it is difficult to understand how gas can exist in natural cavities in the coal when no such cavities have ever been discovered sufficiently large to correspond with the immense quantities given off. It is equally difficult to comprehend how gas can exist in a liquid state. Mr. Wood's experiments showed that under a pressure of several hundred pounds, the volume of gas given off through the solid coal did not exceed 15·72 cubic feet per hour.

The fatal results produced by sudden outbursts are unfortunately too well known to need description. Had the boreholes not been arranged as described, the writer believes that sooner or later a sudden outburst would have resulted.

The method of working coal which admits of frequent settlements of the overlying strata, and leaves no space for gas to accumulate, but at the same time allows it to be regularly given off, must be preferable to the system which causes the pillars of coal to be crushed, contains a large area of unpacked goaf, and prevents the gas from escaping, except by sudden outbursts. The latter usually take place

cubic feet. If this cavity were filled with inflammable gas, at atmospheric pressure, it would require about 36,300 feet of fresh air to render it harmless. The gas would, however, be under a certain amount of pressure, consequently would require a greater quantity of air to dilute it. If five atmospheres are assumed, the same sized cavity would require about 181,500 cubic feet, or at ten atmospheres 363,000 cubic feet. If at the same pressure Mr. Lindsay Wood* obtained in a borehole 32 feet in the solid coal, say 461 lbs., the air necessary to dilute one acre of gas half an inch thick, would be about 1,000,000 cubic feet. If these figures are multiplied to correspond to an opening one or two inches thick, or to an area of 10 acres (or, say, 10,000,000 cubic feet), it may be imagined that a cavity or cavities may be formed of sufficient capacity to contain the immense volumes of gas which have been suddenly given off and met with in actual experience.

Many instances could be given, especially in South Yorkshire, of the large volumes of gas discharged by sudden outbursts, sufficient to foul the largest quantities of fresh air in the best ventilated collieries. From the description given in the Midland Institute Transactions, Vol. IX., page 73, a current of air equal to 40,000 cubic feet per minute was fouled for several consecutive days. Except in the case of faults, no structural difference has been shown to coincide with the locality of an outburst. Where a fault exists, different conditions will naturally arise.

To form a theory based on the foregoing facts. It would seem, that as the main or upper seam of coal is worked out, the intervening strata may be looked upon as an inverted bridge or girder, encased at one end by the solid coal, and at the other by the consolidated pack, having the

*A Paper read before the North of England Institute of Mining Engineers, June 19th, 1880.

least resistance in the middle, where the pack has not been much compressed. As the distance from the coal face to the solidified pack increases, the girder (the strength of which is inversely as the length) becomes weaker, the consequent deflection (or curvature of the intervening strata) forms a cavity which becomes filled with gas as it gradually exudes from the coal, the total load increases until the breaking strain is reached, when the strata becomes fractured, and the pent up gas (probably the accumulation of weeks) escapes at great pressure. What the pressure may be will probably afford arguments for discussion. There are reasons for believing it will exceed at the moment of fracture the pressure stated by Mr. Lindsay Wood. With reference to other theories which have been advanced, it is difficult to understand how gas can exist in natural cavities in the coal when no such cavities have ever been discovered sufficiently large to correspond with the immense quantities given off. It is equally difficult to comprehend how gas can exist in a liquid state. Mr. Wood's experiments showed that under a pressure of several hundred pounds, the volume of gas given off through the solid coal did not exceed 15·72 cubic feet per hour.

The fatal results produced by sudden outbursts are unfortunately too well known to need description. Had the boreholes not been arranged as described, the writer believes that sooner or later a sudden outburst would have resulted.

The method of working coal which admits of frequent settlements of the overlying strata, and leaves no space for gas to accumulate, but at the same time allows it to be regularly given off, must be preferable to the system which causes the pillars of coal to be crushed, contains a large area of unpacked goaf, and prevents the gas from escaping, except by sudden outbursts. The latter usually take place

when least expected, and become intensified by reason of the solid pillars of coal.

The practical results obtained from a regular system of boreholes may be said to be—When an inferior coal underlies within a certain distance the seam being worked, it is better to drain the gas regularly (that is, as it is given off) by a number of boreholes, placed at convenient points, but sufficiently close to affect each other.

The system of boreholes is only supplementary to that system of working which admits of the strata being regularly broken. To put down boreholes in pillar working would be a matter of guesswork, and would not, (except under special conditions), be attended with beneficial results.

Much more might be written on this question. The writer believes that sudden outbursts of gas are the result of the system of working, and are preventible. There is no effect without a preceding cause.

It will be understood that in a pit producing a thousand tons of coal per day, and where the line of face already described is a mile distant from the pit shaft, other matter might be referred to, especially as regards the proportion of large and small coal.

It seems strange, considering the uniformity of conditions connected with the strata, that so many different systems should be adopted. The writer ventures to give one out of several illustrations.

A seam of coal 4 feet thick is now being worked by two different collieries at the same depth, and under precisely the same natural conditions. One colliery, after several attempts at long-wall, is working on the pillar system owing, it is stated, to the bad roof, which prevents any other method being worked safely or profitably. The adjoining colliery is working long-wall most successfully. The cause of the difference may be briefly described as follows:

Owing to the unstratified nature of the roof, it breaks if carried too far on timber, or lengthway on the face. The long straight line of face, which works well in the system described in the first part of this paper, could not possibly be worked in this case. But by working one stall a certain distance in advance of the next, and carrying the packs close up to the roof, the unstratified clod is kept from falling until the coal face has advanced so far that it is not interfered with. By keeping the steps straight and uniform, for the same reasons as previously mentioned, regular lines of fracture are induced. In this case the coal is worked plumb end, and makes a larger proportion of round coal than in the pillar working at the adjoining colliery.

Other instances could be given to show how the effect, instead of the cause, has been considered. Natural peculiarities connected not only with the coal, but with the under and over-lying strata, require equal consideration with the coal itself.

The writer will now endeavour to show that coal will be worked at a much lower depth than is generally believed. The two main difficulties in deep mining are:—

(1) The pressure due to the superincumbent weight.

(2) The increase of temperature, due to the greater depth from the surface.

As regards the first, it has been shown that a proper system of working allows the subsidence of the overlying strata to be regular, and, by the weight being thrown on the goaf, a large portion of the pressure is taken from the coal face. By this means the coal is saved from being crushed.

Further advantages may be obtained by holing in the dirt above or below the coal, and thereby lessening the resistance. By packing the goaf close up to the roof and ripping above

the same, the height of the roadway can be maintained at a reasonable cost, sufficiently long for the coal to be won. Roadways made in the goaf, which gives off no inflammable gas, when consolidated, are preferable for ventilation to those driven in pillars of crushed coal. The area of the roadways can be maintained and sudden outbursts avoided either by the system which causes frequent breaks, or by bore-holes, or by driving return air-ways in the overlying seam.

There are other matters connected with the working of deep coal, amongst others :—

That the subsidence of the land is more regular, owing to the increased thickness of strata and number of laminations. The damage to property, &c., will consequently be less. Besides, not having to leave pillars for surface support, the average yield of coal per foot per acre will be more in the future than in the past. Independently of surface considerations, the advantage of increased yield will result from a better knowledge of mining.

In connection with surface subsidence, it may be mentioned that, at the end of every six months, levels are carefully taken on the surface. The longitudinal sections (taken one chain apart) extend from the solid coal back into the goaf, and show the first and supplementary subsidence.

The air can be changed more quickly by long-wall than pillar working. Assuming the sectional area of the roadway can be maintained (for the reasons already stated), the increased volume of pure or fresh air blowing on the men will make the atmosphere more endurable.

The natural temperature of the strata, although it may be reduced for some distance from the shaft, by the above means, still there is no material difference at long distances in bye.

In addition to the foregoing, there are the natural advantages of:—

Less water is met with in deep than in shallow mines.

Probably the cost of pumping water in the past will go a long way towards reducing the increased cost of maintaining roadways in deep mines, interest on additional capital, &c.

Inflammable gas has not been met with in greater quantities at one thousand yards than in mines at one-third that depth.

The temperature at Ashton Moss has not increased in the same ratio as expected.

The rate of increase is one degree for every 76·9 feet in depth, as compared with 1 degree for 60 feet given by the Royal Commission appointed to inquire into "the probable depth of working coal, and "duration of the English, &c., coal fields."

The local conditions connected with certain water-bearing strata in the Ashton district may have some bearing on this difference.

Having resided for about twenty years within a few hundred yards of Astley Deep Pit (for many years the deepest mine), and only a short distance from the adjoining colliery of Ashton Moss (which is the deepest in England, the coal now opened out being rather deeper than 3,000 feet), the writer has had many opportunities of seeing the effects of the superincumbent weight. The conclusion arrived at, after many inspections of the roadways and coal face in the collieries mentioned, and other deep mines (including the deepest in South Wales), is, that coal will continue to be worked as deep as it is proved to exist.

The last generation of colliery officials expressed doubts as to winning coal at 500 yards deep. Their fears were

working by pillar were preferable at certain depths, and not any particular thickness, because I can quite confirm what Mr. Dickinson says as to very thick mines being worked by long-wall. But it is a difficult matter to work a mine, say 6 feet thickness, with a rock that will not break until the face has advanced, say, 40 yards, and when it does break, everything has to go before it. What I wished to convey was that some seams would be worked better by continuing the pillar system than by working long-wall.

Mr. MARTIN: With reference to the two seams Mr. Garforth referred to, one working long-wall and the other pillar and stall, can there have been circumstances on the surface which rendered modifications necessary in the working?

Mr. GARFORTH: No; there was no difference. It was a matter of detail below. It was exactly the same seam and under similar conditions.

The further discussion of the paper was deferred until after the paper has been published in the Society's Transactions.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XVIII. SESSION 1885-6.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, December 1st, 1885, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

The President, H. M. ORMEROD, Esq., F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for, and declared unanimously elected ordinary members of the Society, namely:—

ROBERT BRYHAM MAWSON, Westleigh Collieries, Westleigh, Leigh, near Manchester.

CHARLES EDWARD NEWTON, C.E., of Sale Bank Cottage, Sale.

JAMES FIELDEN UTTLEY, of Glen Luna, Mayfield Road, Kersal.

The following are the recent additions to the Library:—

Belfast Natural History and Philosophical Society: Report and Proceedings, Session 1884-85.—*From the Society.*

Chester Society of Natural Science: Proceedings, No. 3.—*From the Society.*

Chesterfield and Midland Counties Institution of Engineers: Transactions, Part 3, Vol. XIV.—*From the Institution.*

Dulwich College Science Society: Seventh Annual Report, 1884-85.—*From the Society.*

Edinburgh Royal Physical Society: Proceedings, Session 1884-85.—*From the Society.*

Hertfordshire Natural History Society and Field Club: Transactions, Parts 5-6, Vol. III.—*From the Society.*

Leicester Literary and Philosophical Society: Report of the Council, 1885.—*From the Society.*

Liverpool Geological Association: Transactions, Vol. IV., Session 1883-84.—*From the Association.*

Ditto, Science Students' Association: Proceedings, 1884-5.—*From the Association.*

London Geologists' Association: Proceedings, No. 3, Vol. IX.—*From the Association.*

Ditto, Institution of Mechanical Engineers: Proceedings, No. 4, August, 1885, General Index to Proceedings, 1874-84.—*From the Institution.*

Ditto, Royal Society: Proceedings, No. 239, Vol. XXXIX.—*From the Society.*

Ditto, Geological Magazine: Nos. 257, 258, November and December.—*Purchased.*

Manchester Field Naturalists and Archæologists' Society: Report and Proceedings, 1884.—*From the Society.*

Midland Institute of Mining and Mechanical Engineers: Transactions Part 78, Vol. X.—*From the Institute.*

Mining Institute of Scotland: Transactions, Parts 4, 5, 6, Vol. VII.—*From the Institute.*

North of England Institute of Mining and Mechanical Engineers Transactions, Part 6, Vol. XXXIV.—*From the Institute.*

South Wales Institute of Engineers: Proceedings, No. 4, Vol. XIV.—*From the Institute.*

Alpine Winter in its Medical Aspects, by A. T. Wise, M.D.—*Presented by the Author.*

Catalogue of Western Scottish Fossils.—*From the Geological Society of Glasgow.*

On the Organization of the Fossil Plants of the Coal Measures. Parts 6, 7, 8, 10, 11, 12, by W. C. Williamson, LL.D., F.R.S.—*Presented by the Author.*

Erratics in the Boulder Clay of Cheshire. Pamphlet by Chas. Rickett, M.D., F.G.S.—*From the Author.*

On Indented Pebbles in the Bunter Sandstone. Pamphlet by Chas. Rickett, M.D., F.G.S.—*From the Author.*

Quartzite Boulders in a Coal Seam in Leicestershire. Pamphlet by W. S. Gresley, F.G.S.—*From the Author.*

have met with representatives of the order Myriapoda in the nodules which are found in the shales beneath the Five-quarters Mine, in the valley of the Irwell, near Clifton.

Mr. DICKINSON: Were the Myriapods you spoke of as found in the Five Quarters Mine at one period of their existence amphibious?

Professor BOYD DAWKINS: No, I think not.

Mr. DICKINSON: My doubt hinges upon that.

Professor BOYD DAWKINS: I am not aware that the myriapoda are amphibious; and the specimens I have are distinctly myriapodous—of the nature of those centipedes which you find under the bark of decaying trees. The body of the creature is divided into segments, with a pair of feet to each segment.

Mr. STIRRUP, in replying upon the discussion, said: On the question of insect remains being found in the coal measures, I think there cannot be the slightest doubt. The insects found in France (photographs of which I exhibited at the time of reading the paper) were not such small objects as to raise any doubt or uncertainty, some of them measuring ten to twelve inches in length. With regard to their being amphibious, we have to judge of the habits of all these palæozoic insects by comparing them with those of living genera. Some of these insects can, singularly enough, be classed exactly with living orders and genera, so near do they come in form and organisation. They have been so well preserved in these shales that the nervures of the wings, which entomologists look to for their classificatory characters and other delicate portions of the organism, are clearly defined. These characters do not support Mr. Dickinson's hypothesis that were all amphibious. There is another point not to be disregarded in the history of the coal measure insects—namely, that they are of such high organisation, that we must look much further back in

St. Petersburg: Institut des Mines: Mémoires du Comité Géologique.
Vol. I., No. 4. Aperçu Géologique du District de Lipetsk, par J. Mouschketoff.
Vol. II., No. 2. Carte Géologique Génerale de la Russie, Feuille 93, Partie Occidentale.
Vol. III., No. 1. Die Fauna des Untern Devon am West-Abhange des Urals.
Journal of Proceedings, Part 5, 6, 7, 1885. *From the Minister of Domains.*

THE FOSSIL INSECTS OF THE PRIMARY ROCKS.

In introducing the discussion upon M. Brongniart's paper on "The Fossil Insects of the Primary Group of Rocks," translated by Mr. Stirrup, and read at the October meeting,

The PRESIDENT mentioned that photographs of the supposed insects had been distributed amongst the members in Part XI. of the Transactions, so that they had all had an opportunity of forming their own opinions. As far as he could judge, the objects figured were as much like insects as those which were found in the lias, and with which he was more particularly acquainted.

Mr. DICKINSON: I do not find in the account of the discussion at the October meeting anything about more allusion to the possibility of their being petrifactions. It seems that nearly all were found in the shale heaps where the coal has been worked open-cast, and not underground, which makes it all the more likely that they are petrifactions, that is petrified by lime or mineral water.

Professor BOYD DAWKINS: I am obliged to Mr. Stirrup for having brought this communication before us. The fact of insects being found in the coal-measures is universally accepted, specimens having been found in Coalbrooke Dale as well as in Bohemia and Westphalia. In Lancashire,

surfaces, in that early age, upon which trees and vegetation grew, affording nutriment and shelter for these insects whose remains we find in the rocks, and that forms of animal life abounded which made of insects their prey. We may not be able to tell much about the flora of the early Devonian period, but here are certain animals that we know at the present day feed on wood and decayed vegetation; therefore we may presume that they must, in those ancient times, have fed on similar material. Most of the insects named in M. Brongniart's paper I should not consider amphibious at all; I should rather conclude that the larvæ of many of them found a habitat under the bark of trees or in the ground. That some of them were amphibious, however, is almost certain.

Professor Boyd Dawkins: I should like to add to what Mr. Stirrup has said, that we have, in the Museum at Owens College, no inconsiderable number of the nuts—the trigonocarpa—some of which have been bored by the beetles or some other of the insecta of those early times.

ON SOME FOSSILS FROM THE PALÆOZOIC ROCKS OF AMERICA, PRINCIPALLY FROM THE STATE OF INDIANA.

By Mr. Mark Stirrup, F.G.S.

Mr. Stirrup exhibited a small collection of fossils, and said:—

The fossils that I have the pleasure of bringing under your notice have been sent to me by a correspondent, now, and for forty years past, resident in the United States.

My correspondent, Mr. Fogg, of Jeffersonville, Indiana, is a native of Manchester, and although so long separated from his fatherland and birthplace, he has not ceased to be

the geological record for their origin and ancestry; and there seems no reason to doubt that they occurred in strata considerably older than the carboniferous. They have been found in the Devonian, and after such evidence, it seems to me that it is more a question of the capability of the rock for preserving such delicate structures than their probable existence. There is a great break or discontinuity between the Carboniferous, where, as we have seen, fossil insects occur so largely, and the Liassic rocks, where they occur largely again. We cannot suppose that insects were non-existent during the intervening Permian and Triassic ages, yet their remains are but rarely or never found. This we must attribute to the character of the rocks which we have, as representing those periods, and in which insect remains could not be preserved. Mr. Wild and I have examined microscopically some well-preserved borings in fossil woods from the Lancashire coal-field—perforations very similar to such as are being made by insects in the woods and forests of our own day. Though we cannot say what class of insects have made these borings; yet that they have been made by insects of some sort there is not the slightest doubt, for in the numerous tubular galleries, there may be seen the excreta which they have left. There are many beetles which make such borings, but M. Brongniart says that he has not been able to satisfy himself that beetles made these particular perforations in the fossil woods, because as yet none of their elytra or wing cases have been discovered. The scorpions which have been referred to as occurring in the Devonian rocks are not true insects, but belong to the class Arachnida. They were undoubtedly air-breathers; they were possessed of lungs, adapting them for life on land, and, as they have carnivorous tastes, they doubtless kept in due subjection the insect life around them. What does all this teach us? Simply that there were land

surfaces, in that early age, upon which trees and vegetation grew, affording nutriment and shelter for these insects whose remains we find in the rocks, and that forms of animal life abounded which made of insects their prey. We may not be able to tell much about the flora of the early Devonian period, but here are certain animals that we know at the present day feed on wood and decayed vegetation; therefore we may presume that they must, in those ancient times, have fed on similar material. Most of the insects named in M. Brongniart's paper I should not consider amphibious at all; I should rather conclude that the larvæ of many of them found a habitat under the bark of trees or in the ground. That some of them were amphibious, however, is almost certain.

Professor Boyd Dawkins: I should like to add to what Mr. Stirrup has said, that we have, in the Museum at Owens College, no inconsiderable number of the nuts—the trigonocarpa—some of which have been bored by the beetles or some other of the insecta of those early times.

ON SOME FOSSILS FROM THE PALÆOZOIC ROCKS OF AMERICA, PRINCIPALLY FROM THE STATE OF INDIANA.

By Mr. Mark Stirrup, F.G.S.

Mr. Stirrup exhibited a small collection of fossils, and said:—

The fossils that I have the pleasure of bringing under your notice have been sent to me by a correspondent, now, and for forty years past, resident in the United States.

My correspondent, Mr. Fogg, of Jeffersonville, Indiana, is a native of Manchester, and although so long separated from his fatherland and birthplace, he has not ceased to be

an Englishman, and is proud, as he says, of calling himself a "Manchester man." He takes a special interest in geology, and has formed a large collection of fossils pertaining to his adopted country. He expressed a wish, some time ago, of connecting himself with our Society, and he has on several occasions evinced an interest in the endeavours that are being made to increase the educational institutions of Manchester and to advance the study of science.

He utters the wish, echoed no doubt by thousands of those who have reached mature years, that the educational privileges which are now accessible to the young people of Manchester had been permitted to him in his boyhood.

My notes are compiled from information given to me in his letters, and also from the Reports of the Geological Survey of Indiana, some of which he has sent me.

The city of Jeffersonville is situated on the north-west bank of the river Ohio (La Belle Rivière of the early French colonists), and on the south-eastern border of the State of Indiana. The fossils mainly come from localities in the neighbourhood, and represent the principal geological formations not only of Clark county, in which Jeffersonville is situated, but also, as you will see from the geological structure of the country, they may be said to represent the whole State.

The geology of Indiana is extremely simple; the rock formations, which do not appear to have been disturbed by any volcanic outbursts, belong entirely to the Palæozoic series, which is represented from the Lower Silurian to the Upper Coal Measures.

I exclude from this notice the surface deposits, such as alluvium and glacial drift, the latter of which covers the northern part of the State to a considerable depth.

Looking at the geological map of Indiana (which was exhibited), you will see the bands of colour, representing

the different formations, running in almost parallel lines from north to south. The oldest strata, the Lower Silurian, crop out at the south-eastern side of the State, and dip under the Upper Silurian and Devonian in due stratigraphical order; the Lower, Middle, and Upper Coal Measures following in regular succession as you approach the western limits of the State. These Silurian and Devonian deposits are purely of marine formation, as shown by the numerous Brachiopoda, Corals, and Crinoids submitted for your examination; many of the shells are also covered with Bryozoa.

The Lower Silurian period of Indiana is represented by the Cincinnati or Hudson River group of beds (the names being taken from the districts in which they occur in the greatest force), and the Upper Silurian principally by the Niagara group, which, by the similarity of its fossils, may be correlated with the British Wenlock Shales and Limestone.

The Devonian period is represented in its earliest stages by the Corniferous Limestone, and its middle stage by the Upper Helderberg and Hamilton.

Of the Carboniferous epoch, the only portion from which I have fossils is the Sub-Carboniferous or Mountain Limestone of English geologists.

The majority of the collection comes from the well-known fossiliferous localities—viz., the Falls of Ohio, and Waldron in Shelby County.

The Niagara and Corniferous formations crop out largely near Jeffersonville, and form in many places along the river Ohio fine bluffs or cliffs, some 200 or 300 feet high. These strata also constitute the celebrated Falls of the Ohio, the river flowing in a series of rapids over their outcropping edges and along the dip, which is almost west. The falls or rapids extend from one and a half to two miles, the water

nents of America and Europe. The same Corals, Crustacea, Brachiopoda, and Echinodermata, now found fossil in both areas, then existed, possessing the same function and having the same habits, and none of them of very deep sea life."

The same generalisation may be applied to the Devonian and Carboniferous deposits, whose marine faunæ, both in Europe and America, exhibit similar and distinctive species; and though this collection has been put together without any idea of comparison or correlation with British fossils, its examination, I think, will have the effect of bringing this fact practically before your eyes.

ACCIDENTS IN MINES AND THEIR PREVENTION.

By Mr. J. S. Burrows, M.E.

PART II.

Accidents Underground, other than Explosions.

Since writing the first part of this paper, which was read before the members of this Society in March last, a disastrous explosion has occurred at the Clifton Hall Colliery, causing the death of 177 persons. I notice that Mr. Arnold Morley, M.P., who attended the inquiry on behalf of the Home Office, and whose valuable report on the case was issued some little time ago, advises (amongst other things) in the Trencherbone mine:—

1. The compulsory use of safety lamps, in the place of naked lights hitherto in use.

2. The provision by the owners of the best kind of safety lamps, to be the property of the owners, and used without payment by the men.

These are two points on which I laid stress in my last paper on explosions, and I was glad to see an impartial observer like Mr. Morley arrive at the same conclusion.

I believe many people are waiting for the Report of the Royal Commission, in the hope that its members, after all these years, may recommend some kind of lamp as being the most reliable. I do not for a moment suppose they will take any such responsibility upon themselves; they will doubtless give us the results of elaborate experiments, but we have these already, and I would earnestly press upon the attention of those who have not yet adopted a good lamp the advisability of doing so without further delay. I mentioned in my last paper the likelihood of gas being given off from the roof when "weighting." Since then I have noticed four instances of this in the same mine which is worked "long-wall"—twice during working hours when the colliers were down, and twice during the night. As these were not first weights, the quantity of gas given off was not very great, though in two of the cases it showed a cap on the lamp of an inch and a half for 60 yards across the long-wall face for half an hour, in spite of a fair current of air, and can be found yet in the break formed when the roof sank, so that there was quite enough to cause an explosion if there had been a defective lamp or other cause of ignition. In the *Colliery Guardian* of April 17th, 1885, Mr. André gives an account of an outburst of gas in a Belgian coal mine, which was so strong as to reverse the air current and suffocate 17 persons. To use his own words, "nothing but the means of ignition was needed to bring about an explosion that must have killed every one in the mine. There was firedamp in abundance, mingled with clouds of coal-dust spread over all the working places, and the whole of the day shift of 160 persons were present. The gas with its clouds of dust moved along in whirlwinds and hurricanes, and must have passed over the lamps with a high velocity, yet every one was extinguished! Never before was the Mueseler lamp subjected

" to so trying a test." Here, then, is one lamp, the Muesseler, which, if not perfect, is very nearly so.

Taking the summary of the Reports of the Government Inspectors of Coal and Ironstone Mines for the year 1883, and leaving out of consideration explosions and accidents on the surface, we find that

Shaft accidents caused..... 97 deaths
Miscellaneous accidents, tubs, &c., do... 246 ,,
Falls of roof and sides do..... 469 ,,

making a total of 812, or six times the number of deaths from explosions—134. True, there is something terrible in an explosion sweeping away at one fell stroke the bread-winners of a whole village, and well may we dread such a catastrophe; but the lives of the 812 killed one by one are equally precious. From the moment a collier enters the cage to descend the pit his life depends to a great extent on some other person's skill and judgment—judgment in providing machinery, ropes, timber, &c., of adequate strength; skill in manual operations, such as winding, signalling, &c.; and in other ways, such as in regulating the system of underground work, ventilation, and in enforcing discipline. To begin with, we find that 97 deaths, or nearly 12 per cent., of the 812 accidents under consideration were caused by accidents in the shaft, 5 of which were from over-winding. Considering that an engine-man often has to make 400 or 500 windings of coal and 50 or 60 windings of men in his twelve hours' turn, we cannot wonder if at sometime or another his nerve should fail him or his machinery become deranged, and therefore, although some few managers object to detaching hooks on the ground that the enginemen are more likely to be careless, the writer strongly advocates their use, as, in case of an overwind, they at any rate give those in the cage a chance of escape from otherwise certain death, not to mention cases

where great destruction of plant has been avoided by their use. Often the knowledge that great issues are at stake unnerves a man just when his utmost skill is required, and I cannot admit any force in this argument against hooks, which, if followed out to its logical conclusion, simply means that the greater the danger the greater is the safety. There should always be a sufficient length of chain between the hook and the cage, otherwise the upward momentum of the cage may knock the hook out of the cylinder. Next we find that 7 deaths occurred from the breaking of ropes and chains. Steel wire ropes, such as are in use nowadays, are easily examined, and, if of good quality, should give ample warning in the shape of broken wires. We adopt the following system: When a new rope is put on, a printed form is hung up in the engine-house, showing the date when such rope was put on, when it ought to be re-capped, and, in another column, the date when such re-capping actually takes place is filled in. Thus, if a rope intended to be on two years and a half is put on to-day, the first time of re-capping would be six months hence, the next five months after that, then at the end of four months, again at the three months' end, and afterwards every two months till the time is up, when the rope is taken off, no matter how good it may seem to be. By cutting off a few feet of the rope at each time of re-capping, the same part of the rope is not always in the pulley when decking the cages, and the manipulation of the wires in capping the rope affords a good index of their quality, as I think steel wire often becomes brittle with age and use. When a new rope is put on we immediately order a new one for stock, so that a rope is five years old when taken off, although it has only been two years and a half in use. Chains are risky things at the best, and, to avoid their use as much as possible, the corners of the cage may be connected by solid iron rods, no

chain being thus required except for adjustment of the length of the rope, and to allow for the upward momentum of the cage, as mentioned previously. Every three months the detaching hooks are taken off, cleaned, and examined, and the chains are put through the fire and examined; the date when this should be and actually is done, is recorded on the same form used for the ropes. Where wooden conducting rods are in use, Owen's catches affixed to the cage have done good service in suspending the cage when the rope or chains have broken; and with wire rope guides Messrs. Brown have introduced a patented apparatus, which is now at work at one of the Garswood Coal and Iron Company's pits, but which the writer has not yet been able to inspect. There are 34 deaths from accidents whilst ascending or descending the shaft. If the cages have sufficient space to clear each other at meetings, and also to clear the sides of the pit, horsetrees, &c., these accidents should scarcely be so numerous. I believe in some pits there are spare rope guides hung in the shaft between the cages to prevent their meeting, though I have never seen any in use.

There are 7 deaths by falling down the shaft from the surface. These are preventible if the mouths of the shafts are properly fenced, and the same remark applies to the mouthings part way down, from which 24 persons fell and were killed.

Nine persons were killed by things falling from the surface or from part way down. If there is a proper cover fixed just above the head of the hooker-on, and the pit is carefully examined and the bricking kept in good order, it seems that the only chance of an accident would be when something fell from the top cage and rebounded from the cover or bonnet of the cage at the bottom, and it is a moot point whether the cage top should be sloping to

protect the men in the cage, or flat, for the sake of the hooker-on. Ice is dangerous in winter if allowed to form on the sides of the pit; but a small furnace at the pit top fed with coke, burning briskly at night when severe frost is apprehended, and allowed to smoulder in the day-time, will prevent this, though the shafts should be gone through daily as well.

Eleven deaths arose from miscellaneous accidents in shafts, the causes of which are not specified. Every pit bottom should have a good road round, well fenced, so that there is never any necessity to go under the cage. The total of shaft accidents amounts to 97, of which our own district is responsible for 11.

In proceeding from the shaft bottom, or "pit eye," a workman has generally to travel engine brows or jigs before he arrives at his working place. We find that the deaths from accidents in such inclined planes amount to 61. A separate travelling road would, of course, obviate all these accidents, except, perhaps, such as might befall roadmen or bank-riders whose work is in such brows; and some day legislation may require such separate travelling roads. But in mines three or four feet thick, to make and maintain a separate travelling road 5ft. 6in. or 6ft. high would entail very considerable expense, especially if the roof required timbering. In our engine brows the men are taken down in the morning and brought up at night in the "run" or "gang" of empty tubs. A wire rope is run under these tubs from the capping of the main rope to the drawbar of the furthest tub, and is supported at intervals by iron rods hooked at both ends, one end carrying the "guard rope," and the other resting on the top of the tub. This is, of course, to hold the tubs in case of a "coupling" or "rolley-hook" breaking; the main rope is carefully examined just like the pit winding rope, and the number of persons to ride

is also specified. As to the jigs, with a view of preventing accidents from tubs coming loose, the rope not being attached, or the jigger starting his full tubs against the empty rope, the writer has put the following regulations in force:—

Wherever one tub is jigged at a time, there must be a proper stop-block at the top of the brow, which must be put in as soon as the empty tub has landed at the top. An iron fork with a pin is placed at the bottom of each brow, to which the rope or chain must be fastened before the full tub is taken off.

Wherever two tubs are jigged at one time, there must be two stop-blocks at the top of each brow—one just at the end of the flat on which the tubs stand, and another a few feet down the brow—both of which must be put in as soon as the empty tubs have landed at the top. When ready for jigging, the second or lower stop-block must not be disturbed until the first one is out and the tubs are at full stretch, so that if any tubs come loose through not being properly hooked, the second or lower stop-block may arrest their further progress. There is also an iron fork at the bottom of the brow for fastening the empty rope.

The following rules and signals are enforced, in addition to the special rules:—

I. No person is allowed to travel this brow while the tubs are in motion.

II. The rope or chain must be made fast to the fork at the jig bottom, immediately the full tubs have landed, and not be unfastened until the jigger is actually ready to go on.

III. Six knocks or rings must be given by the taker-off or jigger; and six knocks, or rings, must be returned by the jigger, or taker-off, before any person be allowed to travel up, or down, this jig, and no further signal may be

given or the tubs be started till the person has arrived at the top or bottom of the brow.

Four knocks or rings must be given to signify that the men are out of the way.

Two knocks or rings, "Go on."

Three knocks or rings, "Go on;" when timber, &c., is coming up.

One knock or ring, when tubs are in motion, "Stop." But whatever rules or appliances you may have you must depend upon some person to use them, and I am sorry to say mistakes are still made through carelessness in not using the means provided.

Trams and tubs account for 102 deaths, a large number—one-eighth of the accidents under consideration. I infer most of these accidents occur on the drawing roads, levels, or pony roads, where the tubs are under the immediate control of the drawer or pony-driver, and it seems that ordinary foresight and care on the part of those immediately concerned should prevent most of these accidents.

There are 5 deaths from machinery accidents underground, which might happen from the bursting of a steam pipe or boiler, or from the machinery being unfenced; and 7 from suffocation by gas, which last certainly seem preventible.

Explosions of gunpowder, &c., caused 34 deaths—another powerful argument against its use if any were needed. But as we have not yet discovered an effectual substitute, the writer can only suggest the use of wooden "stemmers" (the bronze ones are by no means safe), and a strict observance of General Rule 8, Section *e*, which says: "A charge of "powder which has missed fire shall not be unrammed," and Section *f*, which says: "It shall not be taken into, or "be in the possession of, any person in any mine except in "cartridges."

Thirty-seven deaths from sundry accidents, the causes of which are not specified, bring up the total of miscellaneous accidents underground to 246, or 30 per cent.

Lastly come the deaths from falls of roof and sides, 469 in all, or 57¾ per cent. of the 812 shaft and underground accidents. It only seems reasonable to expect that in the process of coal-getting, where we remove Nature's support—the coal—and attempt to keep up the overlying strata by artificial means, accidents must sometimes happen, but I do not think there ought to be so many as there are. Mr. Hall, one of Her Majesty's Inspectors of Mines, points to the smaller number of lives lost from this cause (in proportion to the number of persons employed and tons raised) in the North of England as compared with Lancashire, and thinks that the adoption of the north country system of the deputies or firemen setting the timber in the working places in Lancashire, where the colliers do their own propping, would bring our higher percentage down to something like that of the north. Mr. Hall's experience and practical knowledge, apart from his official position, entitle his opinions to careful consideration, but the writer thinks that the greater apparent immunity from these accidents in the north may be traced to other causes than the deputy system of timbering.

If we turn again to the Government Inspectors' Reports for 1883, we see that in

	Deaths.	Persons employed Underground.	Tons raised.
I. The Newcastle District there were	32 ..	39,637, and	17,420,322
	or 1 to	1,239, or to	544,385
II. The Durham ,,	47 ..	52,091, and	29,273,055
	or 1 to	1,108, or to	622,831
III. The Manchester ,,	36 ..	27,673, and	10,176,912
	or 1 to	769, or to	282,692
IV. The Liverpool ,,	50 ..	33,918, and	13,354,062
	or 1 to	678, or to	267,081

I do not think we can fairly take the tons raised as a criterion, as there may be a difference in the ease with which the coal can be got, in the facilities for getting the men's stuff out, the use of ponies instead of men as drawers, the main and tail rope or other systems easily adapted in flat mines, in a double shift of colliers coming fresh to their work, yet only one shift of day-wage hands, &c.

Taking, then, the proportion of deaths to persons employed underground, we have—

I.	Newcastle	1 to	1,239
II.	Durham	1 to	1,108
III.	Manchester	1 to	769
IV.	Liverpool	1 to	678

And taking I. and II., Newcastle and Durham together, as representing the deputy system of timbering, we get—

79 deaths to 91,728 persons employed,
or 1 „ to 1,161 „ „

And III. and IV., Manchester and Liverpool together, as representing the collier system of propping, we get—

86 deaths to 61,586 persons employed,
or 1 „ to 716 „ „

Or, to put it simply, 5 lives are lost in Lancashire from falls, as compared with 3 in the North from the same cause—a sufficiently startling result. But if you have during a certain number of hours one man working under a dangerous stone which can only fall once, and in another similar place two men, each working half the time under a similarly dangerous stone, and suppose that one man is killed on the same day by the fall of stone in each place, it is quite evident that the ratio of deaths to persons employed is, where two men were employed, half what it is in the first case. Just so in the two districts—in the North we have two sets of colliers, each making, say, 7 hours; and in Lancashire

one set, making, say, 10 hours. Taking the figures for the North, there are—

	91,728	persons employed underground,
of whom, say,	50,000	are colliers making 7 hours,
leaving	41,728	besides colliers.

Now, suppose these 50,000 men made 10 hours instead of 7 hours each, we should only require (other things being equal) 35,000 colliers,

which, added to	41,728	
gives	76,728	persons employed.

And the death-rate would then be

	1 to 971,
as against	1 to 716 in Lancashire,
or	3 to 4 only,
as against	3 to 5 shown by the first comparison.

Moreover, the flatter mines of the North enable the pillars to be worked half-way up and half-way down from each level, which allows each "lift" to be finished in half the time and before the roof becomes bad, whereas in our steeper mines the "lifts" must all be taken upbrow, and it is so much longer before a place is finished and the collier is under new roof. Again, the Lancashire and North Wales coal-field is much more disturbed by "faults" than is the Northern coal-field, and often for some distance on each side of a "fault" the roof is full of "slips," and therefore liable to sudden falls. Moreover, in steep mines worked upbrow there is much more danger in drawing the "sprags" or getting the coal down, as the coal falls or rolls over towards the men. The same may be said of the roof: a falling stone may catch a man some distance from the place from which it actually falls, and more accidents may

therefore be expected. Looking at falls of sides, in a steep mine the higher side of a level hangs over more than is the case in a flat mine, and is much more likely to fall. Furthermore, in the North of England most inquests were formerly, if not now, attended by a legal or other representative on behalf of the men, and the knowledge of this may possibly keep everyone up to the mark in performing his duties. I do not, therefore, think that, having regard to the different circumstances of the two districts, there is sufficient evidence to prove that the north country practice of the deputies setting timber at the "face" produces such marked results as to suggest the advisability of changing our present system of the colliers timbering their own places. In our own mines, for instance, I find that props must often be set immediately the coal has been got down, and before it is filled out. In such cases, and with uncertain roofs, would not the men be tempted to wait for the fireman to come and attend to his own work? True, that in the North the colliers are bound by rule to set props, if necessary, without waiting for the deputy, but you cannot expect a man to do much propping when he knows the deputy will do it when he comes; at any rate, there is less temptation to delay when he knows it is his own work, and has to be done sooner or later by himself. I am quite conscious, however, of the advantage of having many more deputies or firemen (as is the case where they have to timber) who can visit and examine the places and drawing roads so much oftener, and this supervision doubtless has a good general effect.

And here I may say that the workmen might use with advantage the powers given them by the Coal Mines Regulation Act, 1872. General Rule 30 gives the persons employed in a mine power to appoint two of their number to inspect the mine at least once a month; they may inspect the shafts, levels, planes, working places, return air-ways,

ventilating apparatus, old workings, and machinery. This power of inspection systematically used would, in the writer's opinion, be very beneficial to all parties; it would put the officials on their mettle to have everything as it should be, the colliers themselves would not like their fellow-workmen to find their places badly propped or otherwise neglected, and the owners would have an independent report of the condition of their underground workings. Such inspections are usual in the North of England, but I believe they are rarely, if ever, made here. Some men say they would be victimised by their employers if they had to make an unfavourable, yet truthful, report; but I prefer to think that managers would be very glad to know the truth, and would respect the men who warned them of something dangerous. Others, again, seem to think such an inspection, if resulting in a favourable report, absolves the employer in some way from responsibility. This can scarcely be reasoned out. If the pit were in first-rate order there would probably be no accident, and therefore nothing for which the owners might or should be held responsible; while, on the other hand, if danger is pointed out by the workmen, the employers would be doubly responsible if they neglected the warning and an accident ensued. I would therefore urge the men to use the power rightly given them, and satisfy themselves that, so far as human skill can go, the pits are made safe for them to work in, and in doing this they will have, not the opposition but, the cordial co-operation of every right-minded manager. It would show that the workmen took some interest in their own welfare, and the extended information acquired in such inspections would be of use to the men when performing their ordinary duties.

If we refer to the Special Rules in force in this district, No. 19 provides that the underlooker, fireman, or other competent person, shall see that the roof and sides of the

travelling roads are secured where necessary by the persons employed for the purpose; and No. 40 of the same Special Rules provides that the miner shall secure the roof and sides of his own working place, and if he shall not have sufficient sprags, props, &c., he shall cease working and report to the manager, underlooker, &c.; he is also to set sprags or holing props as soon as there is room, and afterwards keep them set during holing, &c. It is needless to say that if these rules were always kept, accidents would be very rare. The actual number of deaths from falls of roof and sides as stated is 469; but if we could get at the number hurt, though not fatally, and also the number of narrow escapes from falls, this total might be multiplied by 10 at least. Undoubtedly, long familiarity with the dangers inseparable from coal mining breeds contempt, and yet I, for one, cannot blame the men for possessing a large share of that physical courage without which much of our mineral wealth would remain ungotten. We must remember that the colliers have their living to make by piecework, and also that in many pillar workings the roof is more or less on the move, and therefore a place which might appear quite safe at this moment may alter for the worse in a very short time. Let us, then, do our part by providing plenty of suitable timber, and by employing none but the best, most experienced, and steadiest men as underlookers and firemen. One cannot help noticing a wonderful improvement in the colliers of to-day compared with those of fifteen or sixteen years ago, and the same may be said of the firemen, underlookers, and managers. The spread of education, too, is on our side, and the systematic school training now required by law must naturally have a great effect in making all concerned more intelligent, and therefore more alive to the necessity of taking every precaution to avoid needless risk.

I must say that I do not feel as hopeful of avoiding accidents from the causes treated of in this paper as I do of preventing explosions. I believe that the Coal Mines Regulation Act of 1872 has greatly raised the standard of management in our coal mines; and though there are, and always will be, numerous cases of pure accidents, yet there are many more fatalities which ought to be prevented by the exercise of foresight and prudence, and I trust, as time goes on, the melancholy death-roll will be steadily reduced. The writer feels painfully conscious that he has not been able to do without accidents in the collieries under his charge, and in conclusion would draw attention to the following points as worthy of consideration:—

1. All material to be of the best quality, and with a large margin of strength for the work to be done.

2. The appointment of none but the steadiest and most experienced men as officers.

3. Separate travelling roads where practicable, and strict regulations to be observed in travelling any engine brows or jigs.

4. The systematic inspection of the mine by the workmen, as provided for in General Rule 30.

5. Every man, whether officer or workman, to do his duty in his own sphere, as if not only his own but every one else's safety depended on his care and vigilance.

Mr. Woodward said Mr. Burrows's very able and comprehensive paper contains a great many points which were of considerable interest to anyone who is connected with practical mining.

The discussion was postponed until the paper was printed and in the hands of the members.

ON THE EFFECT OF ATMOSPHERIC CHANGES UPON THE DEVELOPMENT OF FIRE-DAMP.

Report on the Experiments which have been carried out on this subject at the Archduke Albrecht's Colliery, near Karwin, in Austrian Silesia.

Mr. J. S. MARTIN read a paper on "The Influence of Atmospheric Pressure on the Generation of Fire-damp in Coal Mines"—being a translation from the German report recently published.

Mr. MARTIN said: The paper which I have to bring before you is a report on the influence of atmospheric pressure upon the development of fire-damp in collieries, giving the results of careful and elaborate experiments which were made in a colliery in Austro-Silesia. These experiments are being continued over a period of twelve months; but the results obtained from those made during the first month appeared to the observers so important that they resolved to publish them without delay. Copies of the report, which is in German, were forwarded to the British Home Office by the Austro-Hungarian Consul-General, and a number were sent to Mr. Dickinson for distribution. At his request I have prepared the following translation:—

The great explosions of fire-damp last spring, and the different opinions held by skilled persons and others, as to the effect, which the pressure of the atmosphere exercises upon the development of fire-damp, have caused Herr Ritter von Walcher, in Teschen, Agent for His Imperial Highness Archduke Albrecht, to institute experiments at the Gabriel Colliery, near Karwin. Under Herr Ritter von

Walcher the following officials were engaged upon these experiments:—Bergrath Wm. Köhler, the author of this Report; Schichtmeister Edward Pfohl, Certificated Manager at Karwin; Peter Ritter von Mertens, Civil and Mining Engineer, and Head of the Chemical Laboratory in Trzynietz, and Forstadjunct Rudolph Janowski of Karwin, the latter providing the Meteorological information.

It is entirely denied by some, that any important influence is exercised upon the development of fire-damp by atmospheric pressure; others restrict its influence to accumulations of gas in the old workings, &c., where the gas is not under pressure; whereas others maintain that it also affects, in an important degree, the issue of gas from the freshly cut coal.

Thus, the French Commission, according to the report by Haton de la Goupillière (Annales des Mines, September—October, 1880), came to the conclusion that the effect of atmospheric pressure is at least doubtful, and that, where atmospheric changes might make themselves at all felt, the ventilation of the mine, for safety, should be such as not to admit of its being appreciable.

The final Report, which has been prepared by that Commission, contains the following: "Mallard and Le Chatellier "are of opinion that movements of the barometer are "without influence upon the issue of fire-damp from the "working faces, and, that Lindsay Wood has recently "proved this beyond doubt by direct experiments."

Mallard and Le Chatellier admit—although it is in nowise proved—that a sudden fall in the atmospheric pressure *may* cause gas, which has been accumulated in the old workings, to flow into the adjacent places.

The Commission has not, however, committed itself to the opinion that the effect of a sudden reduction of atmospheric pressure is of such very subordinate significance

(Hasslacher, Zeitschrift für das Berg, Hutten, und Salinenwesen im Preuss. Staate, 1882, page 292).

Schondörff (Zeitschrift für das Berg, Hutten, und Salinenwesen im Preuss. Staate, 1876, page 114), in his periodical work, "Examination of Return Air in the Saarbrucken Coal Mines," refers only to the influence of atmospheric pressures on accumulations of fire-damp in goaves, and old works. He only considers the effect of importance, when the goaves communicate with ill-ventilated places, by fissures and breaks in the strata. He sees no danger in the emission of fire-damp into a fresh air current, in a well-ventilated mine.

The English Inspector of Mines, Mr. Galloway, and other skilled English authorities, have formed a different opinion to that of the French Commission. They hold, that while the atmospheric pressure is not the only factor, still it is the most important, in connection with the occurrence of fire-damp. It must be attributed to their influence, that the law in England requires that, after dangerous gas has been found in any mine, a barometer and thermometer must be placed above-ground, in a conspicuous position, near the entrance.

Nasse has also observed, that the reduction of the atmospheric pressure assists the issue of fire-damp, (Zeitschrift für das Berg, Hutten, und Salinenwesen im Preuss. Staate, 1877, pages 277 to 279). A copy of the diagram, which he has prepared from observations, is given (Appendix A).

The numerous attempts, which have been made to decide this question, have been carried out in various ways. In most cases they have been restricted to a single observation of the barometer, compared with the reports of the underground officials, as to the condition of the air. In other cases comparisons have been made between the lists of explosions and the barometrical charts.

Mr. Galloway prepared a diagram of the atmospheric pressures, and compared it with daily reports from a number of collieries in the vicinity of Glasgow, in which fire-damp was found.

Nasse made daily observations with a safety-lamp as to the quantity of fire-damp, which issued through a stopping, and through the coal, where the stopping was let into it. This stopping was for the purpose of shutting off a fire in the mine.

The Mode of Carrying out the Experiments at Gabriel Colliery, near Karwin.

A. General.

These experiments were carried on from the point of view that the most reliable results would be obtained, if the increase or decrease of gas in the air was frequently proved by chemical analysis, and the results compared with the barometrical movements obtained from a self-registering barometer, placed in the mine.

The experiments were, at the same time, extended to the observation of the influence, which atmospheric perturbations exercised upon the issue of gas. These latter are, however, not in a sufficiently advanced state to allow of being communicated at present. The following results, which have been obtained, are consequently restricted to the former consideration only.

The Gabriel Colliery workings are divided into two distinct panels, the ventilation of each being separately effected.

The one has the winding shaft as downcast and an upcast —206 metres deep—situated 500 metres to the west. The other is ventilated by the "Kunstschacht," which is divided by a brattice, and thus acts both as upcast and downcast.

At the principal upcast shaft there is a newly erected Guibal fan of 12 metres diameter, and, as reserve, an old

one of 7·04 metres diameter. The latter was used when these trials were made.

At the "Kunstschacht" there is also a Guibal fan of 5·69 metres diameter.

For these experiments the district connected with the winding shaft was, in the first instance, chosen. The duration of the experiments and observations was fixed at one year; but the results already obtained are of such importance, that it was considered desirable, that they should be communicated without delay.

B. Barometrical Observations.

In making arrangements for the barometrical observations, the authorities of the Central Imperial Meteorological Observatory, were consulted, and their advice acted upon. Close to the bottom of the downcast (winding) shaft, a Barograph, or self-registering barometer, was placed, (in an iron box built into the side), and the diagrams were removed every second day.

These readings were then compared with a barometer at the surface, duly corrected and laid down on a chart, after allowing for temperature, moisture, &c., for which purpose, observations were made, on the surface, at an intermediate level in the mine, and at the barograph itself, each time the diagram was taken off.

It was necessary to make these calculations, in order to prove whether any error had occurred, in consequence of moisture in the air, or through any irregularity in the pattern on the paper.

The uncorrected readings from the barograph were taken at intervals of two hours, corrected from the data obtained, and projected on the diagrams shown herewith. (Appendix B.)

The readings of the mercurial barometer, on the surface, were taken at 7 a.m., 12 noon, and 7 p.m.; and, occasionally,

during violent or interesting barometric changes, additional observations were made at other hours of the day and night.

These observations, after correction for temperature and moisture, were projected on the same charts as those obtained from the barograph underground. (Appendix B.)

C. Mode of Sampling and Analysing the Air.

The samples were at first only taken at the fan race; but after 14 days, it was decided to obtain samples from another point, where the air—unlike that at the fan race—would be unaffected by gas issuing from the goaves. The 230-metre main level in Flotz-Karl was chosen, as the only working connected with it were a pair of brows in course of driving, and which were about 190 metres in length. At first, the samples were taken in Winkler's sampling bottles, of about 10 litres capacity, which were conveyed there full of water. In consequence, however, of its being necessary to examine a large number of samples, in order to obtain a correct idea as to the gas generated in the mine, and owing to the changes which the air is subject to, from interruptions in the ventilation, opening and shutting of doors, &c., it was decided to obtain average samples for analysis, in which the changes would more or less compensate each other. The taking of each sample, obtained from the fan race, or upcast shaft, extended over a period of 2½ hours, as it was considered that the quantity of gas, which the air would contain, would be so liable to variation from the causes referred to. But in Flotz-Karl, in consequence of the absence of goaves, the samples were only taken every 4 to 6 hours, for the purpose of comparing them with the barometric readings.

The average samples from the fan race were obtained in the manner, which Pieler recommended, by a gas-holder, as

shown in Appendix E. It consists of a zinc cylindrical vessel, with two equal compartments, the one above the other, and fitted up with pipes, &c. Each compartment contained 110 litres of water. The sample is collected in the lower compartment. When about to obtain a sample, both compartments are filled with water completely. The pipe, (6), is so regulated as to allow of the water escaping at the rate of 4 litres per hour, or 96 litres per 24 hours. The pipe, (1), is carried to the place whence the sample is desired. The glass U tube, containing a portion of water, allows of the passage of the air being observed. By opening the tap in pipe (6), and that in pipe (1), the desired sample of air enters the receiver as the water flows out. After the expiration of 24 hours, the sample in the gas-holder, (the average for that period), is bottled off, by the arrangement of taps 2, and 3. The water, flowing from the upper compartment into the lower, expels the air, obtained in the latter, into the bottles (Winkler's). When sufficient bottles have been filled, the operation of obtaining a sample for the next 24 hours is proceeded with.

Winkler's method of analysis, (Technische Analyse, page 93), is that mostly adopted. By this process the air is first passed through a solution of caustic potash, in order to remove the carbonic acid gas. It is then passed through red hot oxide of copper, by which the fire-damp is reduced to water and carbonic acid. The carbonic acid, then formed, is collected in "titrirtem barytwasser," and the excess of baryt ascertained by a known quantity of oxalic acid solution. In this way the quantity of carbonic acid, created by the passage over the red hot oxide of copper, is ascertained, and from it, the quantity of fire-damp which was present, can be calculated. This is a very accurate process; but is not as quick as is desirable, and inasmuch as such a large number of analyses had to be made, it was decided to obtain one

of Coquillon-Schondorff's "Grisoumeters," from C. Heinz, in Aachen. By this arrangement a much smaller quantity of air can be operated upon, and quicker results obtained. Fifty cubic centimetres of the air is put into a graduated tube; it is freed from the carbonic acid by passing through a solution of potash. It is then passed over a spiral platinum plate, rendered red hot by electricity, which resolves the fire-damp, which may be present, into water and carbonic acid.

The carbonic acid, thus created, is absorbed by the caustic potash, and the steam allowed to condense. Then, as two volumes of fire-damp, with four volumes of oxygen, form four volumes of steam and two volumes of carbonic acid, it is only requisite to divide the reduction in volume, which takes place, by three, in order to ascertain the quantity of fire-damp, which was originally present.

Before using this apparatus it was repeatedly compared with Winkler's process, and with careful manipulation gave very satisfactory results, as may be seen from the following table.

Attention is here drawn to the large quantity of fire-damp present in the air at this colliery, when compared with collieries in other districts, and at the same time it may be observed, that analyses have proved this to be the case in the Karwin district also; all the more remarkable, since the collieries there are provided with powerful fans, and especially the Gabriel Colliery, where the result obtained is about three cubic metres, (106 cubic feet), of air, per man, per minute, and even more at some of the other collieries.

In order to see that the gases were thoroughly diffused in the bottles, several analyses were made of the air contained in the upper part of the bottles, as well as in the lower part, which confirmed the opinion of the French Commission, that the diffusion was complete.

The results obtained from the analyses by the Winkler process, and by the "Grisoumeter," were as follows:—

Average Sample.	Volume of Fire-damp.	
	Winkler's Process.	Grisoumeter.
From the Fan Race, 27th June ..	2·51	2·53
Do. do. 28th ,, ..	2·14	2·10
Do. do. 29th ,, ..	2·11	2·10
Do. do. 30th ,, ..	1·77	1·80
From Flotz-Karl, 27th June	2·43	2·40
Do. do. 29th ,, ...	3·12	3·17
Do. do. 30th ,, ...	3·46	3·33
Do. do. 1st July	2·65	2·53

II.

Results of the Experiments.

The barometrical diagrams obtained during these trials, (see Appendix B), show that the atmospheric changes above and below ground were symmetrical. The slight differences apparent are such as not to affect the results ascertained, and may be due to the following causes. The barograph shows a continuous diagram of the changes which occur in the mine, whereas the barometrical readings, on the surface, were, as a rule, only taken three times a day. The diagrams obtained by the barograph may in some slight degree be affected by the pressure of the pencil against the paper, preventing a perfectly complete representation of the movements of the barometer; also by the changing velocities of the fan, the opening and shutting of doors, and other matters in connection with the working of the mine; and further by the fact that the pressure of the air in the mine, as indicated by the barometer, was less than on the surface.

Lastly, in reference to the question of the issue of fire-damp from fresh faces, it will be observed, that the diagram (Appendix B), showing the quantity of fire-damp, contained in the air in Flotz-Karl, during the changes in the atmospheric pressure, is more important, (being the result of the issue of gas from solid coal faces only), than the diagram showing the quantity of gas in the air at the fan race, where the issue of gas from the goaves operates to a considerable degree. It will, however, be seen, that as the quantity of gas increases or decreases in the one case, it does the same in the other. During the period of these observations it was found necessary by the manager to suspend work in parts of the mine on three occasions, consequent upon the presence of a large quantity of gas in the ventilation, as shown in the diagram; viz., the morning of the 9th; the evening of the 15th; and the night of the 19th June.

By comparing the diagram showing the changes in the pressure of the atmosphere with quantities of gas in the air, it will be seen that the following deductions may be arrived at:—

1. That the volume of fire-damp in the air generally increases or decreases as the atmospheric pressure decreases or increases respectively.

2. That the volume of fire-damp in the air depends upon the rapidity with which the barometric changes take place.

3. That the issue of fire-damp does not depend on the actual pressure of the atmosphere.

4. That where, after a rapid rise, the barometer continues to rise slightly, or remains stationary for some time at its maximum, a gradual increase in the volume of gas in the air will set in; or if, after a rapid fall of the barometer, it continues to fall gradually, or remains stationary, at its

lowest point, a decrease in the quantity of gas will become apparent, from which it will be seen that the extreme limits of the atmospheric variations are not the points indicative of the maximum or minimum emission of gas.

If these diagrams be compared in detail it will be observed, that the rapid rise of the barometer, on the 10th to the 12th of June, agrees with the decrease of gas, and that the more gradual rise of the barometer, on the 12th to the 13th June, and the falling barometer of the 13th to the 15th, agree with an increased quantity of gas, that the lessening volume of gas from the 15th to the 18th June agrees with the gradual fall of the barometer after the sudden fall of the 15th, and also that the rapid rise of the barometer on the 19th agrees with the reduced quantity of gas contained in the air.

On the 20th and 21st, the atmospheric pressure was artificially lessened, to ascertain if the issue of gas increased in the mine. A full account of this is given further on.

With the high barometer of the 22nd and 23rd the quantity of gas is small, but it increases as soon as a tendency to fall appears. The partial rise of the barometer in the night of 25-26th, is followed by a decrease, as well as the succeeding fall, by an increase of gas. The exceptionally small quantity found on the 30th June and 1st July, is, in a measure, explained by the rise which set in on the 30th June. Inasmuch as such a small quantity was not observed on any other occasion, even approximately, at the fan-race, it is not impossible that there may have been some mistake in the experiments on that occasion. The quantity of gas may have been greater, and, owing to the doubtful value of these figures, it is not desirable to base any opinion upon the comparison with the large quantity found in the air on the 1st and 2nd July. The increase in the volume of gas on the 3rd and 4th July is attributable to the reduced upward

movement of the barometer, after the rapid movement of the 1st and 2nd, and perhaps also to the partial fall, which occurred on the afternoon of the 3rd July.

On the 4th. and 5th. July, the trials of the 20th and 21st June were repeated.

The large quantity of fire-damp, present in the air at the fan-race, on the 6th and 7th, is explained, partly by the fall of the barometer on the 6th, and probably, still better, by the normal conditions not having been attained after the experiments of the 4th and 5th, although the experiments of the 20th and 21st June did not cause any such change as to affect the samples of air collected on the 22nd and 23rd.

The quantity of gas decreased with the rising barometer of the 7th and 8th of July, and increased from the 8th to the 9th, presumably, with the sudden fall which occurred in the afternoon of the 8th, decreasing on the 9th and 10th as the fall quickly approached its lowest depth, and during the afternoon of the 10th the gas increased during the slight fall of the barometer, remaining the same with a steady barometer, although tending downwards, until the 13th.

In the same way, if the diagrams obtained from the observations in Flotz-Karl be compared with those obtained from the fan-race, they will be found to correspond; apparent differences being readily accounted for, by the difference between average samples of the air taken over a period of 24 hours at the fan-race, and the direct samples of the air taken three or four times a day in Flotz-Karl, as already explained. If, however, these latter samples be mixed together and the results shown, the diagrams will be found almost exactly similar, any slight variations being due to the effect of the goaves upon the air at the fan-race.

A comparison of the diagrams, of the changes in the atmospheric pressure with the volume of gas contained in the air of Flotz-Karl, shows the connection between them

thus: The barometrical fall of the 6th, agrees with the increase of gas; the rise between 8 p.m. on the 6th, and 6 a.m. on the 7th, agrees with the small quantity of gas; and the continued rise from 6 a.m. to 12 noon, with the further decrease of gas; the fall of the barometer, which then occurred, agrees with the increase; and the rise which subsequently occurred, until noon on the 8th, with a considerable decrease in the volume of gas. The sudden fall of the barometer, on the afternoon of the 8th, corresponds again with the rapid increase of gas, after which there is a reduction in the quantity during the gradual rise of the barometer. The increasing quantity between 6 p.m. on the 9th, and 6 a.m. on the 10th, does not correspond with the indications of the barometer; it must, therefore, be assumed, that the fall, which occurred between 2 and 4 p.m. on the 9th, and midnight to 2 a.m. on the 10th, contributed to the increase in the quantity of gas given off.

The large percentage of gas in the air, between 6 a.m. and 2 p.m. on the 10th, is undoubtedly due to the severe fall of the barometer, between 12 and 2 o'clock p.m. The barometer reached its lowest point about 4 p.m., from which hour it had a rising tendency until 8 p.m., followed by a reduction in the quantity of gas present. The fall of the barometer, which then took place, agrees with the increase of gas, and the subsequent rise, during the early hours of the 11th, agrees with the reduction in the quantity of gas. From 6 a.m. to 8 p.m. the barometer fell heavily, and there was consequently an increase in the quantity, and after attaining its lowest point, a tendency to rise set in, accompanied by a lessening in the quantity of gas; the sudden fall, which occurred in the afternoon of the 12th, being accompanied by a corresponding increase in the quantity of gas.

III.

Results obtained by Artificially Rarifying the Air in the Mine.

If the observations show correctly that, generally, the reduction of the atmospheric pressure agrees with an increase in the quantity of gas given off, such increase should also follow on artificial rarification of the air in the mine, the mixture of gas in the mine, during such experiment, being compared with the air in its normal state. The proof of an increased issue of fire-damp, during the artificial rarification of the air in the mine, is an unassailable proof of the relation between the issue of fire-damp and the change of the atmospheric pressure. In order to obtain this information, the following trials were made:—The downcast shaft was closed, while the fan was kept working at its usual speed, and samples of the air obtained, as in the previous cases, from the fan-race and the main level of Flotz-Karl. It was assumed, that the quantity of air, passing through the workings, would be less with the downcast shaft closed, and consequently the percentage of gas present would be greater, and thus falsely represent the actual issue of gas during the trial, to avoid which, the quantities of air passing, both at the fan-race and in Flotz-Karl, were ascertained before and during the experiments, by which means, from the quantities of gas contained in the samples, the number of cubic metres of fire-damp given off were calculated.

The first trial carried out in this manner lasted from 1-15 p.m. on the 20th June to 4-20 p.m. on the 21st; 27 hours and 5 minutes; and were made in the workings connected with the principal upcast shaft as before.

The workings of the "Kunstschacht" were separated by stoppings, and the ventilation continued there in the ordinary

manner. The winding or downcast shaft, (for the workings in which the trials were made), was closed by a tight scaffold, puddled over until all singing of the air ceased, any leakage being immediately stopped.

The fan was kept at its ordinary speed of 80 revolutions, to accomplish which, the steam pressure had to be considerably increased.

The diagram (Appendix C.) represents the results, and shows, that the pressure of the air in the mine was at once reduced 2·5 millimetres, and it varied in correspondence with the readings of the barometer on the surface. On re-opening the shaft, the ordinary increased readings were again obtained.

The issue of gas, according to the observations at the fan-race, rose, from 20·12 cubic metres per minute, to 36·85 during the trials, or about 83 per cent.; and in Flotz-Karl from 4·15 to 5·83 cubic metres per minute, or about 40 per cent. At the second trial, under similar circumstances, the barograph indicated an immediate fall of 2 millimetres upon the closing of the shaft, and, as in the first case, the movements corresponded with the changes of the barometer on the surface. On re-opening the shaft it rose at once 1·5 millimetres, and soon reached its regular level. Previous to closing the shaft the quantity of gas which was issuing, (20·45 cubic metres), as calculated at the fan-race, rose to 30·55 cubic metres per minute, or about 50 per cent., when the shaft was closed; and in Flotz-Karl it rose from 5·33 to 6·44 cubic metres per minute, or about 20 per cent. The air in the mine did not attain its ordinary density for some time after the re-opening of the shaft, owing to the strong rush of air to replace the vacuum.

It may be argued against these results, that if a fall of 2·5 and 2 millimetres, respectively, caused such an important increase in the quantity of gas issuing, such should be

equally marked, in the case of an ordinary fall of the barometer, which has never yet been observed in practice. On the other hand, it may be said that this fall or reduction of pressure, (2·5 millimetres), took place within five minutes, whereas in practice such a fall of the barometer is distributed over a couple of hours at least. Thinking that the quantity of gas given off should be larger, with a still greater rarification of the air in the mine, and as it was proved, that during the foregoing two trials, some air was drawn from the workings ventilated from the "Kunstschacht," it was decided to close it, both the upcast and downcast divisions, in addition to the winding shaft, as before. In this manner the rarification of the air in the mine was brought up to 4 millimetres. At the end of seven hours from the commencement of the trial, the fan ceased to extract air through the mine, although the ordinary water pressure of 60 millimetres was maintained at the fan-race. On re-opening the shafts the water pressure fell to 50 millimetres, owing to the rush of air into the workings, and did not regain its normal level until after three and a half hours. Since it is not known at what time the circulation of the air ceased, the results obtained from this trial cannot be reduced directly to figures. It, however, is evident that there was a very considerable increase of gas issuing, as the analysis of the air showed 6·45 per cent. (10 per cent. for the first two hours, and 5·8 per cent. in the following two hours, etc.) Similar observations taken in Flotz-Karl show that 9·09 cubic metres of gas were given off per minute, as against 3·89 under normal pressure before the trials, or an increase of 135 per cent. It is also to be remembered, that, in all probability, the velocity of the air, for some time before the fan ceased entirely to affect it, was so slight that the anemometer would not work, and consequently the mixture of gas must have been even greater.

On the 19th June (this year, 1885) three further trials were made with artificial rarification of the air in the mine. These were confined to the workings or panel, ventilated by the winding shaft, and were each extended over two hours; the velocity of the air was so slight that the anemometer would not work in Flotz-Karl; hence it is impossible to reduce the results, as regards the issue of gas, correctly to figures. The quantity of gas given off however, must have been very considerable, as only after an hour's delay, could the level in Flotz-Karl be penetrated, owing to the presence of fire-damp.

In these experiments the pressure of the air in the mine was on the first occasion reduced equal to 2 millimetres of the column of quicksilver; but on the second and third occasion, owing to the making tight of the door which leaked, it was reduced 2 millimetres further, or 4 millimetres below its previous normal pressure.

The object of proving and giving the results as to the quantity of fire-damp found at the fan-race was more with a view to completeness, than from the value of such information, as naturally the effect of the fan, when the downcast shaft is closed, is to draw out gas in considerable quantities from the goaves. The value of the results obtained, from the examination of the air at the fan-race, in such cases has reference only to the effect of the change of atmospheric pressure on fire-damp, accumulated in the goaves, a matter already well understood, and not the subject of this paper. But the results obtained in Flotz-Karl may be accepted confidently as the effect of atmospheric changes upon the issue of gas from solid coal, &c., the comparison being made with the air, just before the commencement of the trials, when quite or almost free from gas.

IV.

Atmospheric Condition at the time of the recent Colliery Explosions.

As these trials were made in consequence of the recent great explosions, and as the times of such occurrences must be considered times of considerable issues of fire-damp, the question arises whether the changes of the atmospheric conditions corroborate the results obtained in the foregoing experiments.

The respective barometrical charts (Appendix D.) laid down from the "Isobarren Karten," received by the Imperial Central Meteorological Observatory, show as follows:—

1. Poln-Ostrau, 8th October, 1874.—A high barometer during three days followed by a fall, (of 11 millimetres in 48 hours), during which the explosion occurred.

2. Karwin, 6th March, 1885.—After a high, or somewhat high barometer, a fall, (of 16 millimetres in three days), set in. On the second day of the fall the explosion occurred. During this fall an exceedingly strong issue of fire-damp was noticed at the Gabriel Colliery, which adjoins the Johann Colliery, where the accident took place.

3. Saarbrucken, 18th March, 1885.—The barometer having been high, though somewhat variable, for about seven days, a fall of about 13 millimetres, in two days, occurred, near the end of which the accident happened.

4. Clifton Hall Colliery, 18th June, 1885.—For eight days a high but gradually falling barometer, followed by a more rapid one, about the beginning of which latter the explosion took place.

On the occasion of the accident at Dombrau, on the 7th March of this year, the skilled witnesses, appointed to investigate the matter, were unanimously of opinion, that fire-damp only played a minor part, the principal cause

being attributed to coal-dust. It therefore does not prove anything against the connection between the evolution of gas and atmospheric changes, although it does not distinctly indicate any such connection. The accident occurred during a fall of the barometer of 2½ millimetres in one day, after a moderately high pressure for four days.

These diagrams corroborate the results determined by the previously described experiments, namely, that the quantity of fire-damp given off does not depend on the absolute pressure of the air, whether high or low, as it will be seen, that the four accidents named occurred during a rapid fall, yet, in the case of Karwin only, was the barometer low at the time of the explosion, whereas in the other cases it stood about, or rather above, 760 millimetres, the normal figure, (Appendix D).

V.

Practical Results of the Experiments.

The following arrangements have been made at the Archduke's Collieries at Karwin in consequence of these results:

1. The Meteorological Observatory is to be permanent at Karwin.

2. The object of the observations shall be:—

(*a*) To reduce the barometrical readings to the form of a chart or diagram.

(*b*) To watch for approaching atmospheric disturbances by the study of the "Isobarren Karten," issued from the Central Imperial Observatory.

(*c*) To warn the manager and officials of the approach of such atmospheric disturbances.

3. The manager, under whose authority the observatory is placed, shall, upon the approach of such disturbances of

the atmosphere, after a high barometer, inform the officials in the mine of the approaching dangers, and prohibit blasting when possibly dangerous, as well as withdraw the men from any places likely to be affected in a dangerous manner.

Mr. Dickinson said: It may perhaps be thought that this Society has been rather late in entering upon this question; but it is really not for want of its having been recognised by the Council. It is now, I believe, some years ago since the Council discussed the question as to who could best give us a paper; and it was unanimously settled that our late friend Dr. Angus Smith should be asked. Dr. Smith undertook to write a paper on the subject, and I furnished him with a good deal of MS., in order to help him. In the end he wrote to Professor Dawkins, who first brought the subject before him, as follows:—"I must give an answer to your question about the mine explosions. I should be glad if some one would examine it; and, considering my previous attention to mine air, I might be asked; but I have really a great deal on hand at present, and I should like it to devolve on some one else. There is a very great deal to do. The examiners of coal gases would require to be themselves examined. I am not much inclined to believe that barometric pressure has much influence. Some it must have. There are a few cases in which barometrical pressure evidently has had some effect; there are many cases in which no effect has been perceptible, and these the most numerous, I fancy. This shows the need of examining the condition of the coal as to the power of retaining gases, and also the retention of the same in coal, floors and roofs; also the condition of retention; in short. I am frightened at the magnitude of the subject, and

fear it would not come in merely as a slight addition to my usual work." That letter was dated November 16th, 1882.

Mr. MARTIN observed that it was not to be wondered at that Dr. Smith should have shrunk from the investigation single handed, when they saw the list of eminent scientists and practical miners who were engaged upon the experiments in Silesia, where they had full control of one or more collieries for that purpose.

The discussion of the subject was adjourned.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XVIII. SESSION 1885-6.

WIGAN MEETING.

At the ORDINARY MEETING of the Members of the Society, held on Friday, January 8th, 1886, in the Mining School, Wigan;

W. S. BARRETT, Esq., Vice-President, in the Chair.

DESCRIPTION OF SCREENING ARRANGEMENTS AT BRINSOP HALL COLLIERIES.

By A. H. LEECH, M.E.

The long-continued depression in the coal trade has rendered the question of cleaning and screening coal of the utmost importance to all coal owners, and this must be the writer's apology, if one is needed, for bringing this paper before the Members of the Manchester Geological Society.

The good old times, when almost anything that looked black would sell as coal, have passed away, and complaints of dirty coal now are one of the ills which every colliery manager has more or less to bear.

At most collieries the working cost is down about as low as it can be got, consistently with their safe and proper

working, and the margin between the cost and selling price so small, that the chief points to which a colliery manager should direct his attention, in order to make a place pay, appear to be: 1. to raise the coal in as round a state as possible; 2. to minimise breakage in screening; and 3. to keep the coal perfectly clean and free from dirt.

In 1882, the state of trade and increasing competition determined the directors of the Brinsop Company to improve their method of screening coal. Two kinds of coal are made after the slack is taken out, viz., cobbles and main or round coal. Under the old system (which is shewn in dotted lines on plate I.) the coal had to be raked down the screen, and the loose pieces of dirt and bass picked out of the screen itself.

As at many other collieries, the Arley mine is of a very soft nature, and often contains irregular bands of dirt, black shale or inferior coal, a good deal of which has to be taken out at bank.

Much of this chipping was done in the coal truck, and this, with the constant trampling of the screeners, made a considerable quantity of slack in the wagon itself, and caused much annoyance to everybody. Besides this, the method was altogether a very laborious one, and, with a dirty seam, anything but efficient. In order to obviate the necessity of using the pick in the coal wagon, and to spread the coal over a larger area, so as to give more cleaning room, it was arranged, after some consideration, to put up a travelling belt to each screen. After visiting a number of collieries in the neighbourhood, where belts were at work, the writer decided on using steel wire belts in preference to those made of hemp or cotton, and for two reasons: 1. Because the hemp, a solid belt, would carry on the slack made in chipping to the round coal or cobble wagon, whilst with the wire belt this slack would pass through into a

shoot beneath. 2. It was thought that the wire belt would stand the constant chipping better than other kinds of belting, and that it would not be affected by damp weather.

This belt is of special make, and it is the invention of Messrs. Silcock and Sons, of Warrington, by whom it is manufactured. It was first used at the Hulton Park Collieries, near Bolton.

A sketch showing how the belt is woven will be seen in the corner of Plate II., Fig. I. It is exceedingly simple in construction, and is readily joined or repaired.

The dimensions of the belt are:—

Cross Wires ..... 3 B.W.G.
Wires forming the Mesh .. 8 B.W.G.

The mesh of the belt is $1\frac{1}{2}$ in. by $\frac{1}{2}$ in., width 4 ft., length between centres of drums 16 ft.

The arrangement is shewn in plate I., in plan, elevation, and section. On each side, and running the length of the belt, is a plank, fastened down by brackets, on which the chipping is done. This plank is plated with sheet iron. The slack, which is made in chipping, falls through the meshes of the belt on to the shoot A., and thence into the slack wagon. The coal after passing over the belt drops into a screen in which the "cobbles" are taken out, and so into the "round coal" truck. To admit of the belt being tightened by the stretching pedestal, the top plate of the cobble screen is fastened by means of two strap bolts having long screws, so that it may be easily adjusted to the length of the belt.

Each drum on the driving shaft is provided with clutch gear, but this has never been used, having been found so so far unnecessary. The drums are 20 in. in diameter.

After these travelling bands had been erected, it was found that one or two hands were still required at each screen to rake the coal down the screen on to the belt, for

the reason that if the screen were made at such a gradient that the coal would run down by its own gravitation, the slack would not be taken out thoroughly. In order to save this labour—as an experiment—a shaking screen or riddle was put up below the second length of bars, and was worked by two eccentrics, one on each side, on a counter shaft driven from the screen engine. The riddle was made, in the colliery workshops, from the wires of an old conducting rod, the sides and ends being constructed of T iron with two strengthening bars running at equal distances across the riddle. Although this took out all the slack, and saved hand labour, it was found that instead of spreading the coal in a thin layer across the belt it threw it in heaps, rendering it difficult to take out the dirt and bad coal; it also broke the large lumps of coal. Another and fatal objection to the riddle was that it shook the whole heapstead, which, to say the least of it, was not desirable. For these reasons this riddle was shortly afterwards taken out, and the present arrangement, consisting of a movable screen, erected.

This idea was originally suggested to the writer by the movable bars of a patent mechanical stoker, and afterwards confirmed by a visit to the collieries of Messrs. Brooks and Pickup, Towneley, near Burnley, where a very ingenious arrangement is in use—the invention of a Mr. James Landless. In this instance the whole length of the screen is fitted with movable bars worked by saddle cranks, and driven by bevel wheels from a main shaft running the length of the screen. A similar arrangement is in use at most of the large collieries of Belgium and Germany, where it is known as the Briart screen, from the name of its inventor M. Briart, Chief Engineer at the Marmiont and Bascoup Collieries, which are the most extensive in Belgium.

At Towneley they are able to screen over 100 tons per hour by this arrangement, which is, undoubtedly, by far the most effective system, for its purpose, the writer has ever seen. It is almost needless to remark, however, that the Towneley colliery proprietors are exceedingly fortunate in having no dirt to deal with.

The Brinsop screen differs very materially from the one at Towneley. 1. In the method of applying the lift; 2. in the movement of the bars themselves; and 3. the Brinsop screen is very much lighter.

The details of the Brinsop arrangement are shown on Plate II. The movable portion is fixed at the bottom of the second length of bars, which have a gradient of about 19½ in. to the yard. The inclination of the former being about 14½ in. to the yard.

The motion is obtained from two eccentrics (*aa*), one on each side of the screen, having a throw of 8 in., and worked on a counter shaft driven from the screen engine. Working in the groove of each eccentric is a lever (*b*) 4 ft. 9 in. in length, which is lifted by the motion of the eccentric, and falls down by its own weight together with that of the moving bars. The other end of each lever is fastened to a pin (*c*) bolted on the side of the screen, and at 15 in. from this end the screen is lifted. The screen itself consists of two sets of bars, one of which is fixed (*d*) and the other movable (*e*), these being arranged alternately. Both sets are fastened together at the bottom end by means of a rod which runs through holes drilled at the end of each bar and rest on a piece of angle iron *(f)* running across the screen and fixed by a strap bolt on each side. At the upper end the fixed bars are bolted down to a bar of iron (*g*) which like the angle iron is held in its place by two straps. The heads of the bolts are countersunk. The movable bars are 4 in. longer than the fixed ones, and are also bolted on to a

bar of iron. This bar is turned at each end, so as to admit of a roller *(j)*, 3 in. in diameter, which rests on a lever, acting in a similar manner to those fixed on the tappet rods of a Cornish engine, and thus giving motion to the screen. The upper ends of the movable bars are made shallower so as to allow of their dropping down about ½ in. below the top of the fixed bars. The throw of the eccentrics is 8 in., and the levers are so arranged as to give a stroke of about 2½ in. to the moving screen at its upper end, raising it 2 in. above, and allowing it to drop ½ in. below the fixed bars.

The space between the upper length of the screen and the movable portion is taken up by a plate (*k*) about 14 in. in width, which works on hinges at its upper end.

The screen gate is fixed just above this plate.

The motion of the Brinsop screen differs from that of the Burnley screen in this respect, the latter has a forward movement as well as an upward one, the bottom end of the bars resting on a rocking shaft; whilst in the Brinsop screen there is only an upward motion, this single movement being quite sufficient to carry the coal down and spread it evenly over the coal belt.

This arrangement has been in use for some time, and is working in a perfectly satisfactory manner, there is not the slightest oscillation in the heapstead as in the case of the jigger, there is no breakage of the coal in the screen, and it saves the wages of two hands.

The moving bars make about 65 strokes per minute.

Since these belts were put up another improvement has been effected, which is shown in Plate I. Before this was done the inferior coal and dirt taken off the belts were thrown together on the floor of the screen, and afterwards trammed away and tipped on to the ground in the front of the screen where it was sorted. All this involved a considerable amount of work, and occupied too many hands.

LI
BRINSOP
Coal Belt

In order to save labour and avoid excessive breakage of the inferior coal amongst the dirt by tipping, a second belt has been put up to each screen. These dirt belts (*bb*), as they are called, were made at the colliery workshops, of three old flat hemp ropes laid side by side, they are 15 in. in width, and 37 ft. in length between the centres of the drums, which are 2 feet in diameter. These ropes are fastened together by means of rivets, 15 in. apart, through and at right angles to the belt, and are joined together at the two ends by iron hinges.

All the dirt or inferior coal is thrown by the screeners—as it is picked off the coal belt—on to these dirt belts, where it is again sorted; the good coal is chipped away from the bass, and is put down the trough (G) into the main coal screen, the remainder passing on to the front where it is divided, the dirt going down the trough (D) into tubs, and the inferior coal down the shoot (E) in front into carts for land sale.

The drawing on plate I. shows one-half the heapstead.

The whole of the machinery is driven by a single engine, having a cylinder 8½ in. in diameter, a stroke of 18 in., and geared about 22 to 1.

Figure 2 shows an indicator diagram of this engine, giving an indicated horse-power of nearly 2·5, at a speed of 50 revolutions per minute.

In conclusion, the writer trusts that this short paper may be of interest, and that descriptions showing what has been done in the way of screening at other collieries may follow.

ON SINKING WITH A TAIL ROPE.

By Mr. George Wild.

On the termination of the lease of the late Bardsley Colliery Company, by the exhaustion of the mines worked by them, viz.: Two-feet Peacock and Old Mines of Ashton-under-Lyne, the owner of the estate determined to prove the Royley Mine, which is thought to be identical with the Arley of Wigan and neighbourhood, and which was expected to be met with at about 160 yards below the Old Mine, or 300 yards below the Black Mine, of the Oldham and Ashton-under-Lyne district. The colliery and pumps having been stopped several weeks, preparations were begun in August, 1884, by pumping and winding out the water accumulated during the stoppage, repairing the shaft damaged by the water falling down, and by the continued crush or creep of the strata common to worked-out mines. Repairs being completed, sinking was commenced in the Diamond Shaft, (which was both the winding and pumping shaft), and as a longer rope than those in use was necessary, this was accomplished by passing a round wire rope about forty yards long through a strong oak plank fitted in the lower deck of the cage, and securing it by a pair of cramps, the spare rope for letting out as sinking proceeded being wound on a pulley in the upper deck, which pulley was locked in addition to the cramp. This apparatus acted very well whilst sinking from the Old Mine to the New Mine (a distance of sixteen yards), the *debris* from the sinking being landed at the former mine and thence sent up the shaft in the cage as often as the shunt was full of laden tubs, the sinkers coming up to the landing until the hooking was completed and the shunt replenished with empties.

The New Mine was reached at 16 yards, the depth from the surface being about 562 yards, and here, in strong undisturbed ground, were made preparations for sinking the remaining 140 yards necessary to reach the Royley Mine.

The object of securing good ventilation was arrived at by driving to the upcast (Victoria) shaft, which had been sunk to the New Mine in 1863, and tapping the water in that shaft and clearing out the sludge, &c., which had accumulated. The ventilation being established, the shaft was bell-mouthed, to give room for making a suitable landing place for prosecuting the lower length of sinking; good shunts were made to hold tubs sufficient for accommodating the sinkers, as well as the colliers who were getting coal in the New Mine for use on the premises. The winding ropes were lengthened and the pit conductored, so that the material could be raised to the surface by both cages from the new landing place, and the tail-rope again used for a short distance as before.

As it was necessary to put on a longer rope as the sinking proceeded, it was also found advisable to somewhat alter the mode of putting on and taking off the tail-rope, this was accomplished by fixing at the end of the shunt, which was 30 yards long, a drum with winch-handle, and properly horned to hold the necessary length of rope, which for convenience was made only 80 yards, and hung its full length under the cage; this served until we were 80 yards deep, after which a length of 160 yards was put on.

The rope in this fresh arrangement was capped at each end, the upper end being passed through the oak plank fitted in the cage bottom, and made secure by passing through the eye of the capping, an iron pin $1\frac{1}{4}$ inch diameter, which rested on the iron washer with which the hole in the

plank was faced, and in groves on each side of it, and was further secured by two short pins passing throught the main pin and into the plank.

The tail-rope on being taken off was wound upon the drum at the end of the shunt, and the cage-end of it hooked up on a peg ready to take hold of when the shunt was emptied, and attached to the cage in the manner just described; it was then wound off the drum by raising the cage the rope's length. The lower end being hooked to the hoppet in the usual manner; descent was made by the men, sinking operations resumed, and the tubs in the shunt filled from the hoppets in the customary way.

A moveable iron-plated scaffold, running on rails, whose top was level with the shunt-plates and cage-rails. Side-planks for protection from the *debris* in tipping, &c., which were also removeable for entering the "half-round." A stout plank with gas-pipe handrail three feet high, and kept in position by iron pegs through the scaffold, removable for the purpose of hooking in the cage, coupled with the fixed handrails round the shaft, constituted a neat and safe arrangement.

The diagram No. 1 will explain the arrangements referred to, but may be conveniently recapitulated here: Figs. AA, tail-rope attached to cage bottom and to sinking hoppet; B, moveable landing-scaffold set back from cage-line when pulling from sinkers, but set forward to cage-front, when hooking tubs in cage, and filled in behind with an iron-plated block to joint with the platform plates; C, wooden conductors, to which were attached the hand-rails which guarded the fronts and sides of the open shaft; D, shelter-scaffold to protect the banksman from wet, &c.; E, cages running from surface to New Mine when required; F. sinking-hoppet; G, crab to raise the sinkers in case of

stoppage of winding machinery, and to put in air-pipes, &c.; H, drum to take in or let out tail-rope when the cages were required to run to surface; II, plan and elevation of cage-bottom, showing mode of attachment; J, enlarged sketch of sustaining-plank and attaching-pin; K, air-pipes for ventilation in sinking. The rest will require no reference to here.

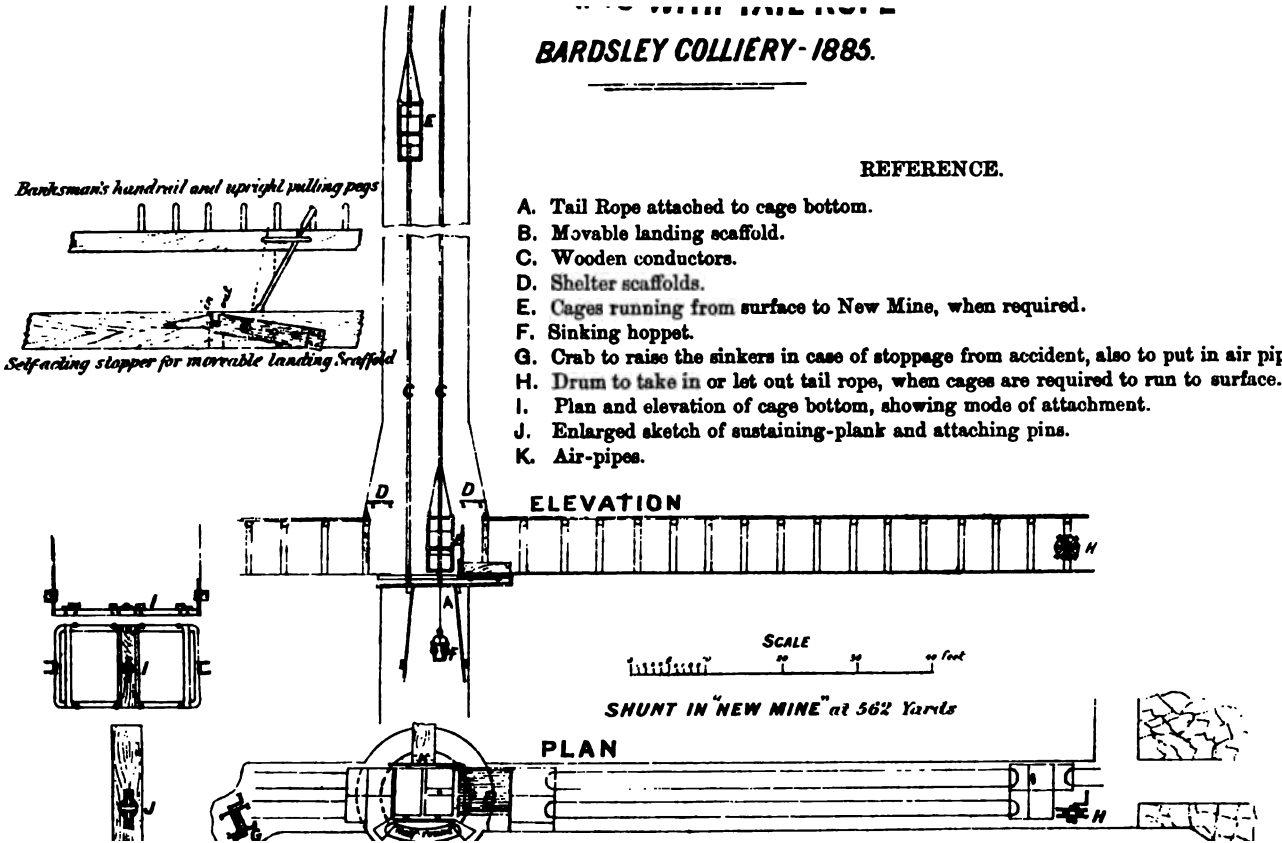
The putting on or taking off of the tail-rope did not occupy more than five minutes, and was done at the change of shifts and at meal times, unless sooner rendered necessary by the progress in filling the tubs.

We had several reasons for using the tail-rope with advantage to the engine (which was a single-cylindered one of about 70 horse-power) in being able to add balance-weight to the opposite cage or side to that we intended to sink with. The ropes being flat ones, and the drums and other fixings adapted for that kind of rope only, it was felt much safer, with ropes weighing over three tons each, to balance, and add the tail-rope, which only weighed three lbs. to the fathom, as it not only placed the engine quite above its work, but gave less risk than in the application of the strong brake-power necessary in the case of a single rope of nearly four tons in weight. The shaft also contained a double set of pumps for 250 yards from the surface, and wooden conductors and horse-trees, so that the time necessary for steadying the hoppet with full length of free rope and long run to the surface, coupled with the oscillatory motion, resulting from a single engine, determined us to adopt the tail-rope, with short run to the landing and a clear pit, in preference to the long run to the surface with its attendant risk in a thickly-timbered shaft; it also enabled us to slowly raise, by the engine, the strong and heavy hanging scaffold used when walling the shaft, an

operation often necessitating the use of a separate steam or manual-labour-capstan.

By taking the above course we were able to supply the coal consumed on the premises from the New Mine, and also very much lessen the risk from anything falling down the shaft (through either accident to the pumps or other causes), by contracting the openings at the landing-place by scaffolds both fixed and movable. The risk from over-winding, a fruitful source of accident during sinking operations, was also obviated, as neither cage was ever brought near the surface whilst the sinkers were in the shaft. In order to provide against the men being kept in the bottom of the shaft in case of unavoidable stoppage of the winding machinery, we fixed a crab with rope, pulley, and seat-horse in the offside mouthing, which, however, was never called into requisition except for putting in air-pipes, &c. In fact the arrangement worked so satisfactorily that I could see no difficulty in going 1,000 yards, or even double the depth of the landing, say over 1,100 yards, and moreover the raising of coal might be carried on for any portion of the twenty-four hours without change in the method adopted; of course the time taken up in winding coal would to that extent delay the sinking operations but sinking and coaling might be carried on alternately. The shaft was not a wet one, but at these extreme depths where this arrangement is most advantageous, we seldom find much water in the strata.

We had scarcely a hitch during the sinking, and reached the coal sought on the 28th May, last year, at the depth of about 702 yards from the surface. The temperature in the solid coal at that depth was found to be 76° Fah., and in the solid strata consiting of black shale forming the roof of a half-inch coal at 604 yards deep, 69° Fah.


BARDSLEY COLLIERY - 1885.
REFERENCE.
A. Tail Rope attached to cage bottom.
B. Movable landing scaffold.
C. Wooden conductors.
D. Shelter scaffolds.
E. Cages running from surface to New Mine, when required.
F. Sinking hoppet.
G. Crab to raise the sinkers in case of stoppage from accident, also to put in air pipes, &c.
H. Drum to take in or let out tail rope, when cages are required to run to surface.
I. Plan and elevation of cage bottom, showing mode of attachment.
J. Enlarged sketch of sustaining-plank and attaching pins.
K. Air-pipes.
Bankman's handrail and upright pulling pegs
Self-acting stopper for movable landing Scaffold
ELEVATION
SCALE
SHUNT IN "NEW MINE" at 562 Yards
PLAN

The tests were taken at depths of 1666 and 1372 feet respectively, below sea-level; top of shaft being 440 feet above that datum.

Should these few notes disclose anything advantageous to others sinking under similar circumstances, or be the means of eliciting accounts of successful undertakings of the same nature from more experienced members, the writer's object will be attained.

Mr KNOWLES said he hardly thought the tail-rope could be applied with advantage in sinking a new shaft from the surface, because he considered it would be more costly to use a tail-rope in the latter case than to use a rope from the surface to the bottom.

The SECRETARY (Mr. J. S. Martin) pointed out that the object of the paper was to show the advantages of using a tail-rope in the event of sinking from an exhausted mine to a lower depth.

Mr. HEDLEY took it to be that sinking with a tail-rope was to enable the proprietors to go on working coal at the time that sinking operations were in progress. That had been done in Wigan district very recently, in the case of a sinking from the cannel to the Arley mine. The getting of cannel went on during the day and sinking progressed during the night, thereby enabling the ordinary work of the colliery to proceed as though no sinking was being carried on. Such appeared to him to be the special advantage and object of sinking with a tail-rope, and when the result was to keep the colliers in employment he thought the practice was much to be commended.

Mr. LEACH said he did not think Mr. Wild could have made use of Galloway's Patent under the circumstances he had described, for the reason that he had a lot of pumping in the shaft.

IMPROVED SAFETY LAMPS.

Mr. Robert Winstanley exhibited an improved safety lamp, and read the following paper thereon :—

ON A GAUZELESS SAFETY LAMP.

By Mr. Robert Winstanley.

The lamp which I have the pleasure of bringing under your notice was handed to me by the patentee nine or ten months ago, since which time I have made some hundreds of experiments with it, both on the surface and underground. I have used it in fiery mines for gas testing purposes, and it has been subjected to the highest velocities obtainable, with the most satisfactory results.

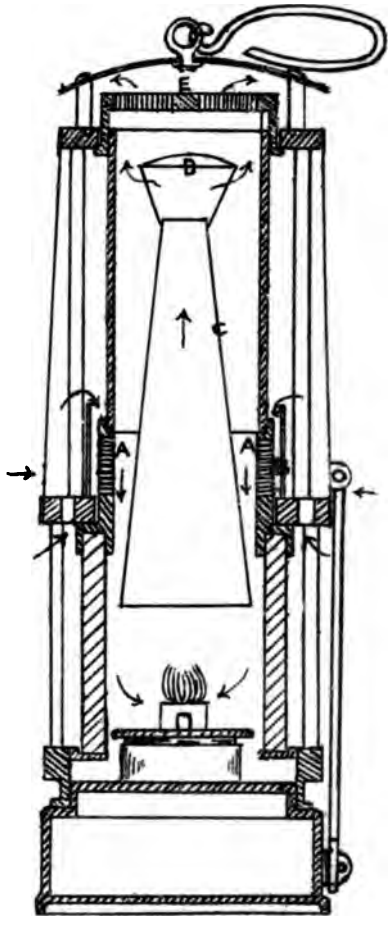
The inventor and patentee is Mr. James McKinless, of Manchester, and until it was put in my possession it had not been in any mine or submitted to any mining expert.

The principal feature of this lamp is that gauze is entirely discarded. The atmosphere (for feeding the flame) enters above the glass and middle ring of the lamp, through a number of very small holes drilled or bored in a belt or band; the diameter of these holes is about $\frac{1}{64}$ of an in., and their length about $\frac{1}{8}$ of an inch. The air passes thence between this belt or band, and an inner shield or chimney to the flame. On the outside of the inlet holes (and inside the tin shield or bonnet), there is attached to the middle ring of the lamp another shield or band, which protects the inlet holes from a strong current.

The products of combustion pass through a chimney or tube (similar to the Mueseler chimney); the top of this chimney is reduced to a diameter only sufficient to pass the ordinary results of combustion. Attached to the top of the chimney is a cap or belt which collects soot or other

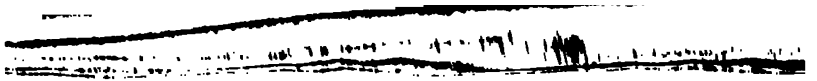
Trans. Man. Geo. Soc., Part XIV., Vol. XVIII.

To illustrate Mr. R. Winstanley's Paper on a Gauze-less Safety Lamp



HALF SIZE OF LAMP.

A. Belt, or Band, with small in-let holes.
B. Shield, or Band, to protect in-let holes from strong currents.
C. Chimney.
D. Cap, or Belt, for collecting soot, &c.
E. Horizontal Plate, with small out-let holes.



unconsumed particles. On the top of the main cylinder or tube of the lamp, is a horizontal plate in which also are a number of small holes of a much greater length than their diameter, and through these the burnt gas and products of combustion escape. A theory has been expressed with regard to safety lamps, that only sufficient air should be admitted to feed combustion, and the outlet sufficient to pass the results of combustion freely. In the lamp now before you, this theory is reversed,—a large quantity of air being admitted and the outlet limited to the greatest nicety, but allowance is made for choking in a dusty mine, and when the lamp is placed in gas, a quantity is admitted which ignites immediately and produces an excess of carbonic acid gas, for which there is not sufficient outlet, and the flame is at once extinguished. In some lamps (the Marsaut for instance) the burnt gases resulting from interior explosion are in part momentarily retained by the shield or bonnet, and tend to assist in the extinction of the lamp by mixing with the feed air.

The construction of the lamp exhibited, goes in direct opposition to this theory, the results of combustion are prevented from falling down inside the bonnet and re-entering the lamp ; it does not require any such assistance in gas, and in my opinion the theory expressed by Mr. Marsaut under ordinary conditions affects the lighting power of the lamp to some extent.

Although the lamp now shown is not the first I experimented with or tested, the principle is the same, but whilst it has been in my possession several modifications and improvements have been made at my suggestion. Having charge of a colliery at which an under-ground fire and explosion occurred in 1884, (Limehurst Colliery, Ashton-under-Lyne,) I have had many opportunities of testing this lamp under all conditions. In order to put out the fire

referred to, the mine had to be flooded with water, and the reopening has been a hazardous operation: large accumulations and out-bursts of gas have had to be contended with, and under no conditions has the lamp failed, it being extinguished immediately on coming in contact with gas. The lamp has been tested by C. E. Rhodes, Esq., the Manager of Aldwarke Main and Car House Collieries, Rotherham, at his lamp testing apparatus, and he reported to me, that it has stood better tests than any lamp previously tried, as at the highest velocities it goes out entirely.

At a velocity of 21 feet per second of an explosive mixture of gas and air, it went out immediately, at 50 feet per second it went out immediately, and the result was the same at 50 feet per second both in an uphill and a downhill current. I am of opinion the same result would be obtained if the explosive mixture was travelling at a velocity of 100 feet per second. It appears to me this lamp complies with all the conditions laid down by Henry Hall, Esq., one of H. Her Majesty's Inspectors of Mines, in a paper he read before this Society, viz.:—

1. It is self extinguishing in an explosive mixture (either in still-gas or at the highest velocity).

2. It is impervious to ordinary draughts.

3. If canted sideways for more than a few seconds, it will be extinguished before the light can impinge on the glass and break it.

4. It is ample and strong in construction. Other advantages are,—that this lamp can be examined at a glance without fear of any part inside the bonnet being out of place. There are no weak parts to require renewal, or repair, or become red hot (like wire gauze), it is easily cleaned with an ordinary wire brush. I omitted to say the lamp has been used for eight hours by colliers in a dusty place without choking or going out.

Something may be said about the cost of this lamp; and ; will be apparent to any one, that the first cost will exceed hat of some modern lamps, but when it is considered that here are no gauzes requiring renewal, this fact will help in ltimately bringing the cost down to a reasonable sum.

The weight is at present heavier than need be, by several unces,—the proper weight may be taken at 3 lbs. 5 oz.

In answer to an enquiry Mr. Winstanley stated that the ost of the lamp he had shown came to about 10s. each, but ith a large demand for them the cost of making would be uch reduced. Replying to other questions Mr. Winstanley id the lamp had always gone out at once in an explosive ixture, whether stagnant or travelling at a moderate or igh velocity.

Mr. W. PICKARD expressed an opinion that the tin shield ould tend to keep up the heat of the inner shield.

Mr. WINSTANLEY said the object of the shield was to revent the men from burning their fingers. There were ent holes in the shield, and it did not in use get any hotter an that of the Mueseler or of the Marsaut lamp.

The CHAIRMAN observed that the question of improved fety lamps was one of the most interesting that could come efore the Society, and he thought their thanks were due to y gentleman who brought forward a lamp that showed y improvement whatever on those already in use.

Mr. WILLIAM CLIFFORD, mining engineer, of Sheffield, lso exhibited an improved safety lamp, and submitted the llowing paper in description of it:—

TESTING A NEW SAFETY LAMP.

By WILLIAM CLIFFORD, M.E.

So far as the writer is aware no serious attempt has been ade up to the last two or three years to test safety lamps t high velocities.

Those undertaken in connection with the Midland Institute at Aldwarke Main Colliery, with the apparatus designed and developed by Mr. C. E. Rhodes, have practically settled the relative safety or unsafety of most of the lamps in common use, proving a high but unascertained resisting power in several lamps or types of lamps.

In order that he might judge of the relative safety of a lamp of his own invention, as compared with that of the best of these hitherto unfired lamps, the writer has endeavoured to make an apparatus which would effect that purpose.

The directions in which he thinks he may claim to have succeeded are:—The imparting of a greatly-increased velocity to a mixture in the test box; the application of a practically continuous test; and not limited to one or a few minutes as hitherto, and if need be the mixture may be blown *through* the lamp, instead of over or against it.

The speed attainable by the use of a steam jet is limited and measured by boiler pressure, and an exhausting machine cannot be prudently applied to a mixture liable to be fired; the writer accordingly decided to use a blowing fan, or any machine that would force air steadily, and in sufficient volume and pressure.

The writer's first idea was to make a machine which from its simplicity could be worked by an ordinary colliery official, and which from its cheapness would not sensibly increase the cost of the lamp equipment of a large colliery.

Figs. 7 and 8 show such an apparatus. The air and gas are blown into two separate accumulators, or governors (*a*), by separate bellows or blowers; thence to nozzle *b*, and mixing tube *c*, to which is attached testing box *d*. This apparatus, like the larger one described below, is furnished

ith paper relief panels or doors *e e*, &c., and the test box, ıbe, and nozzle are mounted upon trestles, or tripods.

The aggregate area of inlet and outlet holes of one-half of properly bonneted lamp is a little under three-quarters of a ıuare inch. Allowing for leakage we will take the sectional rea of column necessary to produce a close or blow-pipe ɜst at one square inch; then to maintain a velocity of 200 ɜet per second in such a column we should require 83·3 ubic feet per minute. This can be obtained easily and teadily with a pair of ordinary double-blast bellows, or even wice the quantity, and so allow of an open test.

Figs. 9 and 10 show another arrangement which the riter tried where he could obtain a good fan blast at ufficient pressure, but the gas was only obtainable at the rdinary pressure of the service mains. The object in using wo holders or compressors is to keep up a continuous test, ne being filled while the other is being emptied. Only one as used, as, owing to the smallness of the only available as-pipe, the use of two was impracticable. With one he btained actual tests of 100 feet per second for about 65 ɜconds, but better facilities and gas supply being obtained t the Sheffield Gas Company's Neepsend Works, a second ɔmpressor was not made.

The arrangement now used is shown in Figs. 1, 2, 3, 4, , and 6. It consists of a test box (A) shown in Section, nd Plan in Figs. 1 and 2, and parts of it enlarged in Figs. , 4, 5, and 6. Its internal cross section measures 12 in. igh, and 5 in. wide. (B) Is the mixing tube, 7 in. by 5 in. ıside measurement, and 12 ft. long. In both sides of tube B) and in one side of test box (A) are strong panes of glass ı the former to allow of the reading of the anemometer, nd in the latter to allow of the behaviour of a lamp under ɜst being observed. The test box is furnished with a

hinged lid, which, when a test is to be made, is clamped down by means of a thumb nut, and coarse pitched screw, working in jaws. In the lid is a paper relief panel (*c*), Figs. 1 and 2, to provide for the contingency of explosion. Inside the box and opposite one another and fastened vertically to its sides are two guides of channel brass $\frac{1}{8}$ in. deep, shown in horizontal section by *(ff)* Fig. 6. These hold the wooden slide (*gg*), Figs. 4 and 5, in which the lamp to be tested is placed.

The mixing tube (B) is fitted with relief doors, with paper panels (*cc*, &c., Figs. 1 and 2) arranged as to size and position with proper regard to the cubical contents of the tube.

The nozzle is the largest size, made by Mr. Thomas Fletcher, of Warrington.

The air-pipe is in the centre and is $1\frac{1}{2}$ inches diameter. The gas-supply pipe is two inches diameter. It is the writer's intention to use a larger nozzle in the particular apparatus he is describing. The whole thing may be mounted upon trestles, or, as in this case, upon light brick pillars.

To test a lamp it is necessary to place it in the hole cut in slide (*gg*. Figs. 4 and 5) to fit the lamp's middle vertical section, having previously placed paper panels over openings in mixing tube, and clamped them down. The slide, when in position and its opening filled by a lamp, makes that part of the box towards nozzle and the intervening mixing tube into a practically closed chamber. Supposing it is desired to apply a close test, *i.e.*, a blow-pipe test, a slide of the shape of that shown at *g* (Fig. 4.) is used, the hole in it fitting the profile of lamp. The only escape of air then possible, beyond a little leakage, is through the lamp itself. For an

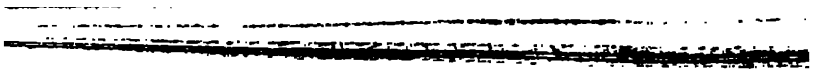
open test, openings *h* in slide *g* Fig. 5 are made, so as to allow the air free play round inlet and ontlet of lamp. The aggregate of these holes is nearly equal to that of air and gas columns combined.

In case a lamp fires the mixture, the paper panels are blown out, and no damage occurs to lamp or box. In the experiments already made the gas supply was cut off by hand on firing, but the writer intends bringing into use an arrangement for automatically cutting off the supply, by the ignited gas burning away a string tied vertically in the tube in front of nozzle and keeping in tension a spring which cuts off gas when released. This arrangement will be readily understood by reference to Figs. 1 and 2. The air pressure is derived from a fan, and is usually from 12 in. to 14 in., W G., at the box. The gas pressure is from 6 in. to 10½ in. W.G. The 6 in. has been generally used, and a close test. With these conditions the Meuseler lamp, closely bonneted, fires in from 17 to 30 seconds. As the writer explained that his object in making experiments was to test his own lamp, he would say that under exactly the same test as that applied to the Meuseler, one of his remained in box for 28 minutes, at which time it went out. Another remained in box 31 minutes without firing externally. Another, fitted with his patent fusible faced gauze, was extinguished in about 12 seconds, the fusing of the gauze cutting off the air supply.

The material of the lamp which remained in box 31 minutes (the one shown) was very severely tried. The litharge cement used to fasten the glass chimney to the bottom of flue was reduced to metallic lead. The top of the glass chimney itself, after it had dropped into the bottom of lamp, was partly fused. The fuel in vessel was volatilised and given off into the lamp in gaseous form.

A "red coat" was formed on gauze in flue (at outlet) which somewhat puzzled the writer until he remembered that the flue of this particular lamp had been brazed to diaphragm with "silver solder" (containing a little silver) and silver after long blowing in the presence of lead gives a red coat.

The writer lays these ideas, opinions, and facts before the society, with the hope that gentlemen interested in lamps and the testing of them, may be induced to challenge or verify them by repeating the experiments on his apparatus.



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XVIII. SESSION 1885-6.

EVENING MEETING AT THE OWENS COLLEGE.

At an EXTRA MEETING of the Members of the Society, held on Tuesday Evening, January 26th, 1886, in the Mineralogical Museum Room of the Owens College, Manchester:

The President, H. M. ORMEROD, Esq., F.G.S., in the Chair.

Professor BOYD DAWKINS said: I may be permitted to call the attention of the Society to two specimens upon the table, as illustrating the fact that, whilst the museum has been put in commission, so to speak, our collections are increasing very fast. You see upon that table two large jaws, containing teeth, belonging to one of the extinct elephantine creatures, the mastodon. One of these specimens comes from America, the other from Asia Minor. I thought it would be, perhaps, advisable to give you this evening an outward and visible sign that really we are improving and largely increasing the collections which the Manchester Geological Society handed over, some years ago, to the custody of the museum trustees.

ON ROCK SALT.

By Thomas Ward, Esq.

Rock Salt is one of the most widely-spread minerals. There are but few countries in which it is not found, as also there are but few geological formations from which it is absent. The sedimentary rocks, with few exceptions, and those chiefly such as were deposited in open seas, show traces more or less of the presence of salt, and salt springs or beds of salt meet us at all depths below and heights above sea level. Being so widely spread over the earth, and so persistent through geological ages, it is evident that the circumstances favourable to its formation must have been common to all places and times. (We may except the primary rocks or all such whose origin has been of an igneous nature, and all countries and districts where these rocks prevail; also, to a large extent, all rocks deposited in the deep sea, and countries formed of such deposits, as well as all coral islands.) In America, the rock salt is met with in very old formations, some of the recent discoveries being in the Silurian rocks. The great salt age of the old world—as distinguished from America, the new world—was the Triassic period with those immediately preceding and succeeding. The circumstances favourable to the formation of salt beds of great thickness existed then more fully than at any other time. The best way to try to understand the workings of nature in the past is to see if anything similar is going on now. In this case we ask the question, Is salt being formed naturally at the present time in any part of the earth? The answer is, Yes; and an examination of the conditions under which its formation is taking place will enable us to come to a pretty definite conclusion as to the manner of its formation in past geologic periods.

The sea is the great reservoir of salt, and from it we find man extracting thousands of tons every year. In doing this he is merely imitating nature. On the shores of all countries where the sun is powerful and where moisture for a considerable period is absent or nearly so (this point is very essential, for however great the heat, if the moisture is great, salt will not form), salt is produced in the small lakes or lagoons left on the low-lying marsh lands. It is very rare, however, to find in these lagoons much salt, for being shallow and the sea water containing not more than 3½ per cent. of salt as an average, little more than a layer of a few inches thick is formed, and the washing over of high tides, and finally the advent of the rainy season soon dissolves the salt thus formed, so that no extensive deposit of salt can occur. Salt forms in this way along the shores of the Mediterranean and Black Seas, also on the shores of the West Indian and other islands in hot countries. When man undertakes to supplement nature he allows the high tides to run into shallow prepared basins, and then shuts off all communication, and gradually evaporates the water till the salt crystallises. In this way solar salt is made in many parts of the world, especially on the shores of the Mediterranean sea. So far we have merely shown that heat applied to sea water causes salt to form, but that unless man interferes no deposits of any extent take place. It is necessary that sufficient time should be allowed for excess water to be evaporated, or crystals will not form.

Besides these lagoons, we find scattered over the earth's surface—more thickly in some parts than others—salt lakes. These lakes have almost invariably brooks or rivers running into them, but no streams flowing out. Where no water runs into the lake it gradually decreases and finally dries up, leaving behind it a deposit of salt. Salt lakes are all found in dry regions, where the amount of evaporation exceeds the

rainfall, or, at least, equals it. If the rainfall exceeded the evaporation, the water flowing into the lake would raise the level until it ran over and formed a brook, river, or stream, and the water of the lake would gradually become fresh. The great region of salt lakes is in the immediate neighbourhood of the Caspian Sea, though there are many others scattered about Asia and parts of Africa. The dry desert or steppe regions of the world are those in which salt lakes abound, and in which salt forms freely at the present time. In America we have a region similar in its nature to that of the Caspian district, viz., the lowlands lying near the Great Salt Lake, between the Wahsatch mountains and the Nevadas. It will be sufficient, however, to look at what is taking place on the steppes of South Russia near the Caspian. It is evident that at one time the Caspian Sea spread over all the low lying country on the western and northern sides. On its retreat it left behind it, in the lowest portions of the country, bodies of water, which form now salt lakes, the intervening land being chiefly swampy, and in the dry season covered with a saline efflorescence. These numerous salt lakes in all ordinary seasons deposit a large quantity of salt, which is collected by the Russian Government and sold. Some of these Lakes, as lake Elton, are of very considerable size, and have salt brooks which drain the neighbouring steppes running into them. We have here on a small scale what seems to have taken place on a much larger scale in past ages. There is no need to enter into the question where the salt comes from. It is there, and it is forming layers or beds of rock salt similar in all respects to those we find in the Triassic and other formations, but much less extensive. In India, again, we find a number of salt lakes in Rajpootana in which salt is deposited during the dry season. One is very celebrated, viz., Lake Sambhur. In the rainy season this lake spreads over a district of from fifteen

to twenty miles in length, whilst in the dry season it is not more than from three to four miles, and presents the appearance of a number of small pools of water with salt-encrusted ground between them. A large portion of the salt used in the neighbouring countries is collected from this lake. Numerous salt lakes have dried up and left their salt behind. In the great desert of Mongolia we are told by Colonel Prejevalsky that many square miles of land are covered over with salt encrustations, and, he says, "the plain of Tsaidam, which at a comparatively recent geological age formed the bed of a huge lake, is now covered with morasses so thickly impregnated with salt, as to be encrusted with a layer in some places half an inch to an inch in thickness." Again he says, "here lies the salt basin of Djaratai Dabas, about twenty-six miles in circumference, presenting a layer of excellent salt a foot thick in the middle, diminishing to an inch round the edges." He say of another lake bed, "this lake bed occupies the lowest part of the whole of Ala Shan, and is 3,100 feet above the sea; it is about thirty-three miles in circumference and encrusted with a layer of pure salt two to six feet thick." In America, also, we find similar dried-up lakes. In Nevada, at the sink of the Carson river, a bed of rock salt, five miles square, evidently forming the bottom of a dried-up salt lake, has been discovered. The salt is very pure and only about fourteen feet thick. Thus far we have seen salt lakes furnishing annually hundreds of thousands of tons of salt, which, if left untouched, would help to form rock salt deposits, and other salt lakes completely dried up and their salt left in large masses of various degrees of thickness. To enumerate only the most important salt lakes would occupy too much time. I will, however, mention the Dead Sea, which, during the dry season, when the Jordan sends down but little water, is at the southern extremity, merely a salt marsh. From the bottom of this sea fine

crystals of rock salt have been brought up by the soundin[illegible] line, and should this salt-forming go on for ages, as seem[illegible] probable, so deep is the sea that huge beds of salt will b[illegible] deposited, which will be mixed up with the sediment brough[illegible] down by the Jordan, and in the course of ages completel[illegible] covered by it and the lake filled. Lake Urumiah, in Asi[illegible] Minor, is a very large salt lake, as is also the famous Grea[illegible] Salt Lake of America, which is merely the remains of a[illegible] extensive inland sea once covering the district. Should th[illegible] climate become drier than now, the shrinkage which wen[illegible] on for ages will go on further and a huge salt deposit wil[illegible] be formed.

Besides the lagoons and inland lakes we have a re[illegible] markable instance of what may be called a combination of th[illegible] two, viz., the Kara Boghaz or Black Gulph on the easter[illegible] side of the Caspian Sea. This is an enormous body of water[illegible], separated from the Caspian by a narrow channel about 15[illegible] yards wide and 5 feet deep. Owing to the enormou[illegible] evaporation and the absence of streams running into th[illegible] Gulph a constant current sets in from the Caspian with a[illegible] average speed of three miles an hour. The result is tha[illegible] the water has become saturated with salt—no animal life i[illegible] existent there—and "layers of salt are being deposited o[illegible] the mud at the bottom." As this has been going on a long[illegible] time, and seems likely to continue, we may expect a mass o[illegible] rock salt similar to those of past geologic ages. Von Bae[illegible] has estimated that the quantity of salt contained in th[illegible] water passing daily from the Caspian into the Kara Bogha[illegible] is no less than 350,000 tons. Schleiden calculates it to b[illegible] 420,000 tons, and Ochsenius raises this to 630,000 ton[illegible] The lowest of these estimates amounts to 127,750,000 to[illegible] per annum. This, if continued for centuries, would form a salt deposit of enormous extent.

Besides the Kara Boghaz, there is in India another distri[illegible]ct

which illustrates the formation of salt. I refer to what is known as the Runn of Cutch. Doubtless a depression has existed here for a long period, but since a great earthquake occurred in 1819, an area of about 10,000 square miles is periodically flooded by sea water. This enormous area lies about the level of the sea, and in some cases just below that level. When inundated, the water everywhere is shallow. The river Looni, a salt stream, runs into it. Over this enormous area, salt is continually being formed, and salt and mud are inseparably connected. It is described as a "desert of salt and mud." On a plan of the old fort of Sindree, which owing to subsidence is surrounded by water, we read, "shallow water, deeper than to the east; intensely saline, a thick layer of salt beneath it." In another place, "shallow water, layer of salt beneath;" then "salt over mud." The salt upon the Runn is generally from one to three inches in depth, but in the Sindree basin it was found beneath the water with a thickness of from three to four feet." The general opinion is that the Runn "has been elevated from beneath the sea during recent geological time." Speaking of one portion of the Runn, Wynne, "On the Geology of Kutch," says: "The miles of mud which had to be crossed show, however, that after wet seasons or partial rains, this Sindree depression would be flooded. It has, doubtless, become reduced in depth by fifty years' accumulation of silt, but this would appear to have been so evenly distributed as to still preserve a hollow where the river ran, and to have been partial or absent where the salt was found three feet thick." There is a gradual depression taking place in one portion of the Runn, and it is very clear from all descriptions of it, that it has been subject to considerable changes, even in historical times. We can scarcely expect to find changes of such magnitude, happening within a few centuries, that occupied an age, in past geologic times.

We have now seen how salt is formed at the present time, with this information we will compare the rock salt deposits of former periods and see if the causes and conditions now operating seem to have been in force in the past, and whether there is anything in connection with the salt deposits that prove this. The first and chief thing is, that almost invariably the salt forms upon mud, and is accompanied by and covered over with mud or mud and sand. Now mud and sand are merely the finer and coarser fragments of rocks carried away by running water and deposited wherever the water reaches a favourable spot for deposition, such as a lake or even the mouth of a river. Every shower of rain creates a certain amount of mud and sand and every brook and stream running into the salt lake conveys during the rainy season—however short it may be—a certain quantity of mud and sand. The mud spreads the more widely; the sand falls nearer the entrance of the stream. Where the district is perfectly rainless, the salt is quickly deposited and is almost pure, and the lake soon dries up. In those cases of dried-up-lakes that we have mentioned, the salt is almost always described as pure. These cases, however, are exceptional, and in dealing with existing salt-depositing lakes we find continual reference to the mud or,—for it is the same thing—clay. Speaking of Lake Elton, Herr Cech says—"The yearly layers (of salt) are separated from one another by a layer of black mud; beneath the fourth layer is found black clay, and underneath this, once more, layers of salt of a more solid quality." Pallas, in his "Travels in Russia," repeatedly refers to the mud. Speaking of one lake, nearly dried up, he says—"Here the rock salt forms a very extensive stratum, as beautiful and pure as crystals; it is immediately beneath a bed of loam." Further on he says "In the pit which we cleared it was evident that the rock salt did not form a com-

pletely horizontal stratum, but had an inflected superficies, and was irregularly waved with grey streaks, and apparently originating from a black mire. Immediately above this bed of salt, there was a waved stratum of grey clay, which forms the whole of the incumbent surface." Again, "After passing an eminence, we saw a saline lake, nearly dry, which had deposited a considerable crust of salt upon its mire." In the report of the examination of the Dead Sea, by Lieutenant Lynch, we read—"The bottom consisted of blue mud and sand, and a number of crystals of salt, some of them perfect cubes." At the southern end, near Jebel Usdum, "the beach was a soft slimy mud incrusted with salt;" and on one of the party landing "his feet sank first through a layer of slimy mud a foot deep, then through a crust of salt, and then through another foot of mud." At a depth of 1,308 feet the bottom was found to be "soft brown mud with rectangular crystals of salt." At Lake Sambhur, in India, we are told that "to reach the thick crust of salt they have to wade some 300 or 400 yards, ankle deep or deeper, through soft, fetid black mud, loaded with sharp-edged salt crystals."

Schleiden, in speaking of Lake Elton, says—"On this old salt, is deposited a blackish mud layer (salt clay) which separates the salt from the next succeeding layer. In 1805 Göbel bored, in the very shallow lake, about 1½ miles from the shore. He found 42 distinctly separated layers of rock salt, the uppermost from 1 to 4 inches thick, the lowest 9 inches thick. The deeper he bored the more solid the salt was, and the more pure. At the hundredth layer the salt was so hard that the iron tool broke." A Russian report of an inspection of the north-eastern shores of the Caspian, says that "the area of the whole of the salt lakes is about 24,000 acres. On the surface is a layer of about 2 inches of pure strong salt, above a layer of black lake mud, underneath

which is a strong bed of salt." Darwin, speaking of the salt lakes of Patagonia and La Plata, says—"The salt rests almost always on a thick bed of black muddy sand." Stansbury, in describing the broad plain country to the west of the Great Salt Lake, says—"The first part of the plain consisted simply of dried mud, with small crystals of salt scattered thickly over the surface. Crossing this we came upon another portion of it, three miles in width, where the ground was entirely covered with a thin layer of salt in a state of deliquescence, and of so soft a consistence that the feet of our mules sank at every step into the mud beneath. But we soon came upon a portion of the plain where the salt lay in a solid state." In the Runn of Cutch the same state of affairs exists.

We have seen now that in whatever quarter of the world salt lakes abound, the same characteristics are to be met with, viz., salt depositing on mud and covered by mud. The mud represents the wet season of the year, the salt the dry season. It is not possible to obtain such full descriptions of salt lakes, nor such accurate examinations of all concerning them as of ordinary lakes, for they are almost always situated in dry desert regions little visited by travellers, and those who frequent them for the salt, only casually, and as it were accidentally, refer to the mud which is almost invariably present.

It is not my intention in this paper to do more than deal with the physical circumstances accompanying the formation of rock salt. I want to show what must have been the geological condition of things when salt was deposited, hence I shall refer but very slightly to gypsum, which almost as frequently accompanies rock salt as clay itself. As both salt and gypsum are held in solution, and are both deposited during the same physical state of affairs, the presence of gypsum does but little to explain the formation of salt.

As the nature of clay, whether in a hard or soft form, and its production by and deposit in water are well understood, it will be quite safe to conclude that, if we find any deposit with clay at the bottom, and the deposit itself mixed up with clay, and clay again covering it at the top, such deposit must have been formed under water into which mud-bearing streams, either large or small, have entered. We have seen that modern salt formations, in almost all cases, are deposits of the nature of which I now speak. I will examine a few sections of the salt formations of past geologic ages, and will not confine my examination to one period or to one country, but will take examples from many places and ages. The diagrams, or coloured sections on the wall, will make the matter more clear. I have not in all cases given the section from the surface, for the depth being frequently so great would require a much longer paper. However, in every instance I have given the rock salt and its immediately overlying, and where possible, underlying deposits.

In North America, especially in Western New York and Michigan, and in Canada, at Goderich and neighbourhood, the rock salt is found in the Upper Silurian formation, and usually lies at a depth of over 1000 feet. I give a section of a boring at Goderich, Ontario. The first 876 feet consists of dolomite and clay, gravel and boulders; the last near the top.

From 879 to 997 feet there is a bed of variegated *marls* mixed with strata of dolomite; from 997 to 1027 is a bed of rock salt; from 1027 to 1060, dolomite with *marls* towards the base; 1060 to 1085, a bed of rock salt; 1085 to 1092, dolomite; 1092 to 1127, rock salt; 1127 to 1207, *marls* with dolomite and anhydrite; 1207 to 1223, rock salt; 1223 to 1230, dolomite and anhydrite; 1230 to 1243, rock salt; 1243 to 1379, *marls*, soft, with anhydrite; 1379 to 1385, rock salt; 1385 to 1517, marls, soft, with dolomite and anhydrite.

(Dr. Sterry Hunt.) Marls are clays, and in this paper loam marl and clay will all be spoken of as clay, being all deposited by water in the same manner.

At Middlesborough, in Durham, rock salt has been found. Here again it is at a great depth. Omitting the formations for the first 785 feet we find from 785 to 1109 a succession of layers of marl, sandstone and gypsum; at 1117 is a bed of marly sandstone very salt; at 1127 feet decayed red marl with salt; at 1136, red rock salt; 1203, rock salt; 1222, rock salt with marl and gypsum; from 1222 to 1337 are layers of gypsum shale (? marl) and magnesian limestone, the gypsum frequently containing rock salt; from 1337 to 1351, rock salt; 1353, marl, containing rock salt; 1354, marl, with gypsum; 1355, impure rock salt. At this point it may be well to observe that impure rock salt means rock salt much mixed with marl. Very often it is difficult to know whether to call a layer marl with rock salt or rock salt with marl. I have brought with me a collection of rock salt, varying from marl with slight traces of rock salt to rock salt with only slight traces of marl, and in a few instances perfectly pure rock salt. It is very rare indeed to find pure rock salt, and in every case that I shall mention the rock salt is more or less mixed with marl. I hold in my hand a piece of commercial rock salt where the percentage of marl is not more than from 2 to 3. I intend, in speaking of the Cheshire salt beds, to point this matter out more fully.

At Northwich, where the salt beds will illustrate the Cheshire rock salt, we find the salt in the Keuper marls. After passing through the boulder sands and clays we meet with red marl, which is succeeded, at a depth of about 45 to 50 yards, by the first bed of rock salt 75 feet thick. Below this we have a bed of hard marl with here and there veins of rock salt; this is 30 feet thick. Under it we meet the second bed of rock salt, which is about 105 feet thick;

below this, as shown by a boring of about 225 feet, there are brown and blue marlstone with rock salt; rock salt, hard blue marlstone. At Droitwich the salt lies in the same formation, and is accompanied by marls in exactly the same manner.

On both sides of the Carpathians, rock salt abounds, most of it in Tertiary formations. At Stebnick, in Galicia, we have a borehole giving the following results :—

ft.	
106	Loam and bluish clay, with gypsum.
14	Blue clay, with single grains of salt.
2	Layer of salt.
17	Bluish salt clay, with fibrous gypsum.
7	Pure rock salt.
3	Rock salt, mixed with clay.
3·3	Hard sandstone.
136·3	Rock salt. The salt was of a fibrous nature at the top; at 178ft. from the surface it was mixed with gypsum; at 188ft. mixed with clay; from 199ft. to 249ft. perfectly pure and transparent; below 249ft. again mixed with clay.
2·5	Green sandstone.
46·9	Rock salt, mixed with clay and sand; lower part pure.
2·25	Grey solid sandstone.
1·4	Pure rock salt.
19·3	Salt, mixed with clay.
1·9	Hard sandstone.
6·2	Rock salt.
2·0	Salt clay.
291·	Rock salt; from 388ft. to 418ft. from surface, more or less mixed with clay, then from 418ft. to 679ft. a mass of pure rock salt:—

This section is very interesting.

Karsten thus describes the celebrated rock salt of Wieliczka, in Poland:—First we have a loam of varying thickness, then a quicksand and a bed of marl with pebbles; this covers the rock salt, which rests on a mixture of salt clay, gypsum, and marl. This salt-clay-marl is the proper formation in which the salt appears, sometimes in masses, sometimes in layers.

At Volterra, in Italy, we have an interesting section.

ft.	
136	Blue clay, with alabaster.
14	Rock salt.
18·6	Clay marl, with alabaster.
13·3	Salt clay, with rock salt.
35·3	Blue clay.
28	Salt clay.
24·5	Marly clay, with gypsum and alabaster.
38·8	Rock salt.

At Dieuze, in the East of France, we have a remarkable section, which reminds one of Göbel's boring in Lake Elton. It shows remarkably thin beds of salt and marl.

Section in shaft at Dieuze, France:—

Metres.	
55·1	From surface to first bed of salt.
3·6	First bed of salt.
0·8	Salt clay.
3·6	Second salt bed.
0·2	Salt clay.
1·3	Third salt bed.
2·3	Salt clay.
2·0	Fourth salt bed.
4·1	Salt clay.
1·0	Fifth salt bed.
1·2	Salt clay.
0·6	Sixth salt bed.
3·7	Salt clay.

And so on, salt and clay alternating in various thicknesses, the last or thirteenth bed of salt, 3·1 metres thick, not being bored through. It is very rare that we meet with such regularity as in this section.

I might continue to give section after section of scores of salt formations, and in almost every case they would be merely a repetition of those already given.

I give one more section, as it is most instructive. In the neighbourhood of Stassfurt, in Germany, a most remarkable deposit of rock salt was discovered some 40 years ago. It is almost the only deposit where other salts closely connected with rock salt, such as the potash salts, have not been washed away, but still remain to show the state of affairs when the salt and they were deposited. The section I give is one out of many, for numerous shafts have been sunk into the salt formation.

A bore-hole at Douglass Hall gives the following section:—

Metres.	
5	Blue loam.
18	Sandstone.
33·5	Slaty loam and clay.
57·7	Clay and gypsum interchanging.
36·5	Gypsum.
4·1	Rock salt with gypsum.
10·5	Dark grey clay, with gypsum in stripes.
5·0	Rock and potash salt.
14·5	Rock salt.

I have a large coloured section of this deposit showing the various beds and their relations to each other.

To make this part of my paper more complete, I will give a few short descriptions of various other rock-salt formations.

At Kulpi, in Armenia, "the rock salt lies between marl and gypsum. The mountain in the remaining part consists of gypsum, marl, rock salt, and sandstone. The marl which accompanies the rock salt is grey—dark grey—reddish, and brownish red, and forms layers which intermix with the gypsum and salt."

At Nachitschevan, Russian Armenia, "the rock salt lies in the clay and forms a nest or pocket of 150 feet in diameter in red and blue marl. The mass of rock salt is broken up by layers of grey marl."

Jebel Usdum, at south of Dead Sea: "This hill consists throughout of a single mass of rock salt, which is covered with a thin layer of calcareous marl, out of which the rock salt projects in many places."

The Salt Range in India: "A red clay, which shows itself particularly in the valleys, is a certain indication of a rock-salt deposit. The salt lies in a hill of this red clay formation."

Wynne, describing the geology of the Kohat salt rock of North West India, says: "Rock salt associated with beds of clay and sometimes earthy impurities." Again, he says: "The bright-red gypseous marl of the Salt Range has no representative here, the clays most closely associated with the salt and gypsum being grey, like the salt itself." Indeed rock salt always owes its colour to the contained marl.

At Usolje, in Russia, the rock salt is overlain by blue marls.

The rock salt in the Alps of the Tyrol and Salzkammergut is rarely found as pure rock salt; it is commonly mixed with clay and marl, to which the name of salt clay has been given.

In Utah, Colonel Fremont speaks of "a large formation of rock salt imbedded in red clay."

It is clear from all the evidence we can gather respecting rock salt that in all geologic ages in which deposits are found, and in all parts of the world, clay is the chief accompaniment of rock salt, and is in most cases mixed up with it. This being so, and clay being deposited in water, we are forced to the inevitable conclusion that salt is a deposit out of water. Now salt is not a deposit of the same kind as clay—that is, it is not mixed mechanically with water so as to deposit in the form of a sediment like sand or clay, but forms a solution, and will never deposit until the solution becomes supersaturated, when it will not fall or be precipitated, but will crystallize out. I want this to be clearly understood, for in speaking of salt deposits we are apt to imagine that the salt has really been deposited like sedimentary rocks. I know of no name by which to characterise properly the salt formation. It is really a crystallization, mixed very often with a clay deposit. The fact that you may keep a salt solution containing 25 per cent. of salt as long as you please without a particle of salt depositing (of course I am supposing that it is kept from contact with the air) at once does away with the common idea that all salt beds are deposited in seas. Such a thing is simply impossible. The water of the sea contains rarely more than 3½ per cent. of salt. Before the salt would crystallize out, the whole body of water must at least contain 26 per cent. of salt. The only way to obtain salt from the sea is to shut off a portion of the water and then evaporate the surplus water to saturation point, when salt will form. This is done, as I pointed out, on the sea shores of many hot dry countries. We can only obtain salt from *salt* water; and as it is not possible to get it from the sea naturally, it is evident that what man does in isolating portions of sea water to make salt, nature must have done on an extensive scale in all ages. Now an isolated

piece of water is simply a lake, and if the water is salty it is a salt lake. It seems to me, therefore, that there is only one conclusion to come to, and that is, that all rock salt formations have been deposited in salt lakes.

There have been various theories started to explain the formation of rock salt. Many have seriously argued that the beds of rock salt owe their formation to volcanic action. This was for long a favourite theory. Beyond the fact that in volcanic eruptions salt has been ejected, or has accompanied other matters, I know of scarcely anything to favour this view. We are always sure that volcanic action is accompanied with intense heat; now the fact, which I have never seen stated before, that the pure rock salt crystal is, undoubtedly, one of slow growth, in a cool liquid, and not of rapid formation in a hot fluid, at once disposes of the volcanic theory. I have here some fine specimens of rock salt crystals, formed within the last few years, in a liquid never more than 60° Fahrenheit in temperature. I have also equally fine crystals formed in a liquid varying from 90 to 120 degrees of temperature. A glance will at once show the difference in their formation. Now I could show you a sequence of salt crystals commencing with the very fine crystal, produced at a boiling heat of 226° Fahrenheit, through the common salt produced about 180°, the fishery about 140° to 120°, and the bay from 90° to 120°. The rule in salt making artificially is, the larger and solider the grain, the less degree of heat, and the longer the time required. Now the rock salt crystal is solider and frequently larger—though crystals do not grow to an indefinite size—and consequently requires less heat and a longer time. The crystals I show you have been subjected to a temperature of about 53° Fahrenheit, for a number of years in a salt mine. I particularly wish to call your attention to these crystals and the manner of their formation. Each is a cube, but

these cubes form in most irregular positions, growing into and on one another in the most diverse directions, insomuch that after a time it is difficult to trace the cubes. I have here some perfect crystals of rock salt, formed in the Triassic age, and I want you to compare the old and new salt together. One particular feature of the rock salt crystal is, that it has three lines of cleavage. I mean the crystal will cleave parallel to each face of the cube, and this feature is common to the crystal of both the Triassic and modern rock salt.

Now I propose to take the Cheshire rock salt district and apply what we have learned to it, and see if it will not be possible to arrive at a satisfactory conclusion as to its history.

Rock salt is found in Cheshire, in the neighbourhood of Northwich, Winsford, and Lawton. At Middlewich and Nantwich, although brine springs are present, and salt has been manufactured for centuries, yet till now, no rock salt has been found, although borings to the depth of about 400 feet have been made. I have a rough map of Cheshire showing the position of the different salt districts, and I have also roughly marked out the boundary of the red marl district, which extends into Shropshire. It is quite possible that there are other beds of salt towards the centre of the county, but I wish to call attention to one fact, that the salt districts occupy but a very small portion of the great red marl area, and mainly the central portion. This may be expressed by saying that the salt formation is not commensurate with the marl formation, but seems to occupy the lowest portions of the great basin in which both have been deposited. I say basin advisedly, for all who know Cheshire will be aware that the Keuper Marls occupy and fill up a very deep basin, and that in the centre the red rocks lie at a great depth. It is very evident then that

whatever was the original area of the great salt lake in which the salt and marls were deposited it must have been at least commensurate with the present red marl area. We may then speak with certainty of the Great Cheshire Salt Lake of the Age of the Keuper Marls. The enormous body of marl deposited throughout the whole of the lake shows us that very considerable streams bearing large quantities of mud must have flowed into the Great Lake, as the Jordan does into the Dead Sea, and as the similarly-named Jordan does into the Great Salt Lake of Utah, and as the Volga, Ural, and other streams do into the Caspian; the Looni into the Runn of Cutch; and as brooks and streams run into Elton and other salt lakes. Now if this Cheshire (I use this term though not applicable to Triassic times) Salt Lake were very deep, as we might judge from the enormous thickness of the combined beds of salt and marl that it was, the difficulty is to understand how in the space of one short dry season sufficient evaporation could possibly take place to make the water sufficiently saturated to deposit its salt in crystals on the bottom of the lake. Judging from the position of the beds of salt—evidently at the deepest part of the lake—a shrinkage reducing the area by many miles must have taken place. Such enormous shrinkage of a deep lake is unknown in the present age and improbable in any age. How then account for what we find must have occurred. It may not be easy, nor perhaps even possible, to explain everything that occurred in the formations of past geologic ages; but that does not prevent us from concluding, with almost positive certainty, on certain leading principles and conditions of formation. I confess at once that the enormous thickness of the beds of rock salt all over the world and their comparatively limited area, but more especially their thickness, has always been difficult to clearly comprehend. But because we cannot

these cubes form in most irregular positions, growing into and on one another in the most diverse directions, insomuch that after a time it is difficult to trace the cubes. I have here some perfect crystals of rock salt, formed in the Triassic age, and I want you to compare the old and new salt together. One particular feature of the rock salt crystal is, that it has three lines of cleavage. I mean the crystal will cleave parallel to each face of the cube, and this feature is common to the crystal of both the Triassic and modern rock salt.

Now I propose to take the Cheshire rock salt district and apply what we have learned to it, and see if it will not be possible to arrive at a satisfactory conclusion as to its history.

Rock salt is found in Cheshire, in the neighbourhood of Northwich, Winsford, and Lawton. At Middlewich and Nantwich, although brine springs are present, and salt has been manufactured for centuries, yet till now, no rock salt has been found, although borings to the depth of about 400 feet have been made. I have a rough map of Cheshire showing the position of the different salt districts, and I have also roughly marked out the boundary of the red marl district, which extends into Shropshire. It is quite possible that there are other beds of salt towards the centre of the county, but I wish to call attention to one fact, that the salt districts occupy but a very small portion of the great red marl area, and mainly the central portion. This may be expressed by saying that the salt formation is not commensurate with the marl formation, but seems to occupy the lowest portions of the great basin in which both have been deposited. I say basin advisedly, for all who know Cheshire will be aware that the Keuper Marls occupy and fill up a very deep basin, and that in the centre the red rocks lie at a great depth. It is very evident then that

whatever was the original area of the great salt lake in which the salt and marls were deposited it must have been at least commensurate with the present red marl area. We may then speak with certainty of the Great Cheshire Salt Lake of the Age of the Keuper Marls. The enormous body of marl deposited throughout the whole of the lake shows us that very considerable streams bearing large quantities of mud must have flowed into the Great Lake, as the Jordan does into the Dead Sea, and as the similarly-named Jordan does into the Great Salt Lake of Utah, and as the Volga, Ural, aud other streams do into the Caspian; the Looni into the Runn of Cutch; and as brooks and streams run into Elton and other salt lakes. Now if this Cheshire (I use this term though not applicable to Triassic times) Salt Lake were very deep, as we might judge from the enormous thickness of the combined beds of salt and marl that it was, the difficulty is to understand how in the space of one short dry season sufficient evaporation could possibly take place to make the water sufficiently saturated to deposit its salt in crystals on the bottom of the lake. Judging from the position of the beds of salt—evidently at the deepest part of the lake—a shrinkage reducing the area by many miles must have taken place. Such enormous shrinkage of a deep lake is unknown in the present age and improbable in any age. How then account for what we find must have occurred. It may not be easy, nor perhaps even possible, to explain everything that occurred in the formations of past geologic ages; but that does not prevent us from concluding, with almost positive certainty, on certain leading principles and conditions of formation. I confess at once that the enormous thickness of the beds of rock salt all over the world and their comparatively limited area, but more especially their thickness, has always been difficult to clearly comprehend. But because we cannot

clearly understand how such enormously *thick* deposits were formed we do not say that the principle of their deposition is unknown. I feel as sure of the method of deposition of rock salt as I do of the formation of white salt in my salt pans. I have an idea indeed concerning the Great Cheshire Triassic Salt Lake. I am pretty well convinced in the first place that the district in which the lake was situated was either a desert, or what is much more probable, a swampy *steppe*, like those in the neighbourhood of the Caspian Sea. Again I am clearly convinced that the climate was not like the present Cheshire climate, but one having a wet season and a dry one. The rock salt clearly shows this. The marl could only be formed in a period of heavy rainfall, as the salt could only crystallize out in a *dry* water-evaporating period. I feel also pretty well convinced that the lake, though extensive in area, was very shallow, and that the dry season caused the lake to shrink very extensively and salt to form in the saturated water left in the deeper parts. If the lake, then, were a shallow one, I may be asked how could such deep deposits have occurred. I at once say that I know of nothing more certain in geologic science than the constantly varying elevation and depression of the earth's surface. Nothing is surer than that all the sedimentary rocks, and all clays and sands, whatever their position at the present moment, whether on the top of the highest mountains or at the bottom of the deepest valleys, were originally deposited under water. All mountain ranges—or nearly all, for some may owe their origin to denudation long continued—have been elevated gradually, and through long-continued ages. This gradual elevation must of necessity either absolutely or relatively cause corresponding depression. My opinion then is, that whilst the Derbyshire hills, and those between Staffordshire and Cheshire, as well as the Peckforton range and its continuation to Helsby were

being gradually elevated, the great Salt Lake—originating as a portion of the sea cut off by the gradual elevation of a part of the sea bottom, was gradually sinking, so that for ages the amount of subsidence might only be small enough to make up for the thickness of the deposit of marl and salt. Another difficulty arises when we come to consider how the salt in this lake could be renewed so that the waters could go on depositing for a geologic age. Again, I say, there is a difficulty, but it is no greater than that which meets us in scores of salt lakes at present, out of which thousands of tons of salt are annually taken without there appearing to be any diminution in the salt forming year by year. I think that when we consider that in a lake having an area probably of from 500 to 1000 square miles, the salt deposits as far as known do not occupy 50, and that the rock salt itself is in many portions nearly half marl, the difficulty does not seem to be insuperable. However, it is quite possible, nay probable, that when the bar that finally cut off the lake from the sea rose, it would be many years before the high tides of the year ceased to wash over it and replenish the lake. And if Dr. Ball's theory as to the enormous tides that occurred in past ages, owing to the moon being nearer to the earth than at present, is a probable one—of which I am not competent to form an opinion, then we see a means whereby the lake might be continually receiving fresh accessions of sea water for many generations. Be this, however, as it may, the fact is that enormous beds of salt were deposited in this Great Salt Lake. We will examine the rock salt itself, and no formation is so capable of telling its history as salt. At present the salt formation has not been bored through, but as we know of one section carried considerably below the great beds of salt, we will examine it. The lowest stratum was 18 feet of hard marl, not bored through. Next followed six feet of pure rock salt, then 81

feet of marl with thin veins of rock salt; then three feet of nearly pure salt; next, 83 feet of marl with thin veins of salt; and this was succeeded by four feet of marl and salt. Thus far it is evident that the wet seasons predominated, and that marl was deposited far more extensively than salt. For a time a cycle of dry seasons seemed to prevail; a great change occurred, and a bed of rock salt varying from 80 to over 100 feet in thickness was deposited. We have here an indication of greatly changed seasons. None of the salt is perfectly pure. Indeed, not more than 20 feet out of the 100 or more is sufficiently pure to be of any commercial use. A portion near the bottom contains less clay, indicating that the rainfall was not so copious or long continued, and that the salt deposited had less mud brought upon it by the streams than in ordinary seasons. The dry seasons, or seasons of less rainfall, were succeeded by some seasons of heavy rainfall, as indicated by the rock salt in the roof of the mines, which is known by the name of "roof rock," or "black rock," and contains much clay. After a time, so much rain fell that for a period sufficiently long for about thirty feet of marl to deposit, practically, no salt formed, for only here and there in this deposit are veins of salt, and as these are perpendicular and run as if deposited in rifts or cracks of the marl, no doubt the salt belongs to the next period, when a change again occurred and another bed of salt, varying from fifty to eighty feet in thickness, was deposited. The whole of this bed is pretty full of marl, though the salt was mined and sold for nearly a century. For an untold period marls were deposited, covering up the rock salt. What was the history of these beds from Triassic times till the time of the boulder clays and sands it is impossible to tell, for these latter lie immediately upon the salt marls. I think there can be no doubt but that we can read the history of this formation

bar of
of a
acting
of a
The
as to
of th
the l
to the
and
Th
the n
in wi
Th
Th
Burn
move
bars
scre
bein
even
T
worl
sligi
jigg
it s
T
S
bee
don
thr
tru
the
co

set of marl with thin veins of rock salt; then three feet of early pure salt; next, 83 feet of marl with thin veins of alt; and this was succeeded by four feet of marl and salt. Thus far it is evident that the wet seasons predominated, nd that marl was deposited far more extensively than salt. For a time a cycle of dry seasons seemed to prevail; a great hange occurred, and a bed of rock salt varying from 80 to ver 100 feet in thickness was deposited. We have here an ndication of greatly changed seasons. None of the salt is erfectly pure. Indeed, not more than 20 feet out of ne 100 or more is sufficiently pure to be of any ommercial use. A portion near the bottom contains ess clay, indicating that the rainfall was not so copious r long continued, and that the salt deposited had ess mud brought upon it by the streams than in rdinary seasons. The dry seasons, or seasons of less rain-all, were succeeded by some seasons of heavy rainfall, as ndicated by the rock salt in the roof of the mines, which is nown by the name of "roof rock," or "black rock," and ontains much clay. After a time, so much rain fell that or a period sufficiently long for about thirty feet of marl to eposit, practically, no salt formed, for only here and there n this deposit are veins of salt, and as these are perpen-icular and run as if deposited in rifts or cracks of the marl, o doubt the salt belongs to the next period, when a change gain occurred and another bed of salt, varying from fifty o eighty feet in thickness, was deposited. The whole of

Mr. DICKINSON said: It was not my intention, when I came here, to be a speaker; I wished rather to listen to one who has paid, I may say, a life's attention to the subject, and whose daily avocations bring him into contact with the practical work of salt manufacture. As some of you may know, I have had to go officially into the Cheshire mines very frequently; and from the very nature of the thing I have for years taken a very lively interest in the subject. But Mr. Ward has put before you matter with which I really am not acquainted. I know the salt districts of this kingdom well; the others that Mr. Ward mentioned, I may say, I know nothing of except from what I have read. With reference to the sections which have been put before you there is one point that strikes me as having been proved recently to be inaccurate: that is with regard to the borings at Middlesborough. When Bolckow, Vaughan and Co. put down their first bore-hole the cones showed a whitish stone which was taken for dolomite, or magnesian limestone, and it was so named in their original section. When Bell Brothers put their bore-hole down at Port Clarence the name of dolomite was again given to beds of this same whitish stone. Since then, however, very careful analysis has been made of it, which has proved it to be gypsum, and not dolomite or magnesian limestone at all. It is a fact, which I believe has been demonstrated through the whole of the borings at Middlesborough, that not a single particle of salt has yet been found below the magnesian limestone. I may say that I have examined the cones of the original bore-hole that was put down, and also the one that was recently put down at South Bank, a short distance below Middlesborough, on the same side of the river. Both of these were put down by Bolckow, Vaughan and Co. I have likewise examined those put down by Bell Brothers, both the original one and the one put down since. The cones

show distinctly that the upper part has been sunk through marl; then there is 300 yards of red sandstone, which is destitute of pebbles; and after that, marl is again met with, followed by the gypsum and rock salt. There is one thing Mr. Ward might perhaps have made clearer—that is, in describing these beautiful crystals of white rock salt. In no mine that I have been in, have I ever seen these white crystals occur except under peculiar circumstances. There must be a marl-stone or something near; this, it would seem, has changed the crystal or absorbed the dirt crystallized out of the salt and left the salt perfectly pure. Possibly Mr. Ward may have met with other instances; I have never met with one myself. There is another peculiarity which I have seen—that was at Mr. Falk's rock salt mine, at Winsford. In the course of working they cut into a small hole, just like a rat hole, in some places about an inch, in others two inches in diameter. It was not perfectly round, but roughly formed, and it was traced from 100 or 200 yards, and when first cut into, it gave off fire-damp. All round that hole, wherever they worked through it, there were crystallizations of this white salt. There were cart-loads of it found around that hole. As to the theories about the origin of the rock salt beds, I think Mr. Ward has stated them very fairly. He has shown the difficulties that lie in the way and has endeavoured to remove those difficulties. There is one advantage in the paper we have heard, it does leave us some ground for consideration; and I think it is better where a paper does not clear everything up perfectly, but leaves something for reflection. I think in these theories about rock salt there is a little left for reflection. We find the rock salt in immense deposits; but how it came there is a question that still may be theorised upon. My own idea is that the rock salt beds have given the salt to the sea, and not that the salt of the sea has formed the salt beds.

The PRESIDENT: I do not know whether Mr. Dickinson has a theory that these crystals, in the process of crystallization, exercise the power to exclude the marl, just as the gypsum seems to have had the power to connect itself together?

Mr. DICKINSON: There can be no doubt that, in the crystallization of salt, as in other forms of crystallisation, there is an affinity which draws like to like.

Mr. STIRRUP said: This subject which Mr. Ward has introduced is one of great local interest, and I think the Society will be grateful to Mr. Ward for having given us so interesting and—I will not say exhaustive—but so full an account of what he considers to be the origin of the deposition of beds of rock salt. I may say also that in Mr. Ward I think we have the best authority on the subject in this neighbourhood. He has shown us that rock salt does not belong to any one geological formation, neither does it belong to any one country. He has laid before us sections of salt deposits in different parts of the world, and it is very curious that in some parts, as in the United States, Nova Scotia, and India, there are salt deposits which certainly are of much older date than any we have in our own country; for, although there is some doubt, I believe, about the geological age of some of those in India, there is not the slightest doubt about those in Canada and Nova Scotia, for above them are found well-known carboniferous limestone fossils. There is one other point—that is, with reference to the gypsum, which Mr. Ward incidentally mentioned, and which, I think he says "does but little to explain the deposition of rock salt." That means, I presume, the cause of such deposition. Now, I take it that it has a great deal to do with any explanation we can give as to the origin of rock salt. I do not wish at all to controvert Mr. Ward's theories, because I am at one with him pretty nearly in the expla-

nation he has given to us; but it is very curious that wherever we find deposits of rock salt, there we find also deposits of gypsum. Mr. Dickinson called our attention to the fact that in those Middlesborough borings, a rock, which was taken at first for dolomite, proved to be gypsum. There is a chemical explanation of the cause of the frequent concurrence of the two minerals—rock salt and gypsum—which I will take this opportunity of mentioning. It is one arrived at by experiments that were instituted and carried on by M. Dieulafait, an eminent French chemist, the results of which were given to the world in an address delivered by him, some few years ago, to the Scientific Association of France.* The views therein expressed as to the mode of origin of rock salt are such as will bear out, in a great measure, Mr. Ward's theory :—

"The phenomena which succeed each other when sea water is evaporated at the ordinary temperature of the South of France are the following:—First, there is precipitated a very feeble product made up of carbonate of lime, with a trace of strontian and of sesquioxide of hydrated iron, mixed with a feeble portion of manganese. The water while continuing to be evaporated, remains perfectly limpid, and, without forming any other deposit than that mentioned, loses $\frac{4}{5}$ (four-fifths) of its primitive volume. Thus a layer of sea water of a thickness of one mètre will diminish by evaporation so far as not to occupy more than 0·20 mètre (one-fifth) without leaving a deposit other than the feeble precipitate mentioned above.

"But, thus diminished by evaporation to $\frac{1}{5}$ (one-fifth) of its primitive volume, the sea water commences to abandon an abundant precipitate made up of a perfectly crystallized substance. It is sulphate of lime with two equivalents of water, that is, gypsum; and so far as its geometrical form and chemical composition are concerned, it is identical with the gypsums which exist in great masses in the stratified deposits of our globe.

* *Vide La Revue Scientifique, 9th July, 1882.*

"As the water is evaporated, the gypsum continues to be deposited; but when the primitive volume is still lessened by $\frac{3}{100}$, the precipitation of gypsum is arrested.

"A very curious phenomenon is produced at this point. After the separation of the last portions of gypsum, the water leaves no longer any deposit. It is necessary that it should lose still $\frac{3}{100}$ of its primitive volume before the precipitation recommences; but then it is no longer gypsum which is deposited, it is the chloride of sodium—marine salt.

"The separation between the end of the deposit of the gypsum and the commencement of the deposit of marine salt is so marked and so easy to recognize that it is utilized largely in the industry of saliferous marshes.

"The workmen allow all the gypsum to be deposited in the ordinary ponds or basins, then the water is made to pass, when deprived of this component, into special basins properly prepared and cleansed.

"They thus obtain a very pure salt, which they can remove, even to the bottom, when they have caused the last mother waters to be run off.

"Marine salt, whose deposit commences, when the water has lost the $\frac{90}{100}$ (nine-tenths) of its primitive volume, is continued until this last tenth be still reduced one-half.

"The salt which is deposited in this interval is salt industrially pure; it is, in fact, commercial salt.

"If one goes further, it continues to deposit marine salt; but there commences to be precipitated with it some sulphate of magnesia, and when there does not remain more than $\frac{3}{100}$ of its primitive volume, it deposits a mixture of equal parts of chloride of sodium and sulphate of magnesia. This is the mixed salt.

"Lastly, when the concentrated water has arrived at the stage of not occupying more than a little less than $\frac{3}{100}$ of the primitive volume, a salt is deposited of a high industrial importance. It is carnallite—a double chloride of potassium and of magnesium.

"Spontaneous evaporation cannot go much further; there remains,

consequently, a mother water which will never be evaporated at the ordinary temperature, even in the hottest regions of our globe. That mother water contains, moreover, some chloride of magnesium.

"Thus the succession of deposits in their natural order is:—

Feeble deposit of lime, with sesquioxide of iron, &c.
Pure gypsum.
Pure marine salt.
Marine salt mixed with sulphate of magnesia.
Mixed salt—chloride of sodium, sulphate of magnesia.
Carnallite.
Deliquescent salt, containing chloride of magnesium."

These experiments of M. Dieulafait appear to throw great light on the probable mode of formation of rock salt, and give a reason for the gypsum occurring so often in juxta-position or mixed up with it. As to Mr. Dickinson's view that the sea derives its salt from salt beds, I must strongly differ from him; for I think that it can be clearly proved that it is not so, but that on the contrary the salt beds are really deposits formed by the evaporation of sea water.

Mr. Richard Barlow: If all formation of salt, spring, as the paper would indicate, from the sea, it still leaves in my mind a complete enigma, as to the origin of the salt itself; and if I am to get any relief from that dilemma I must accept Mr. Dickinson's idea that the sea gathers its salt from the salt beds as well as throws it up again.

Mr. Ward, in responding to the discussion, took occasion to refer to Mr. Dickinson's question about the formation of perfect salt crystals. These crystals, he observed, are almost invariably accompanied by a rather thick deposit of marl. Subsequently to their formation he thought a deposit of clay or mud had covered them rapidly and thickly, and enabled them to retain their perfect form and purity. With regard to gypsum, they had in every salt works a perfect illustration of the deposit of that substance in the formation of "pan

scale." This consisted simply of successive layers of gypsum and salt.

Mr. DICKINSON mentioned the fact, that in Sussex there is a bed of gypsum sometimes 6 feet in thickness, and at its base a bed of selenite varying from half an inch to 3 inches in thickness. Wherever the layer of selenite is thin the gypsum above it is good; but where it thickens out to 3 inches or more, the gypsum is found to be impure.

A vote of thanks to the authorities of Owens College, for having permitted the Society to meet in that building, was passed and carried unanimously.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XVIII. SESSION 1885-6.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, February 2nd, 1886, in the

CORRECTION IN PART XI.

The three last lines on page 284, Part XI., have been misplaced; they should be transferred to the top of page 288.

namely:—

Mr. JOHN WALLWORK, Colliery Manager, Clifton Moss Colliery, near Manchester.

IMPROVED SAFETY LAMPS.

Mr. WINSTANLEY, M.E., exhibited the safety lamp shown at the Wigan meeting in January, and explained the principle on which it is constructed.

Mr. DICKINSON observed that the tube was the invention of the late Mr. Robert Stephenson. That was the principle of his safety lamp, in contradistinction to that of Sir Humphrey Davy.

Mr. WINSTANLEY: Yes; he found out that flames could not be passed through tubes of a certain diameter.

Mr. DICKINSON: Have you had experience of this lamp in a long day's work to see that it does not choke up?

Mr. WINSTANLEY: It has been worked with by a collier for nine hours in the 2ft. and Peacock Mines without being extinguished on getting choked up.

ON WORKING COAL BY LONG WALL.

The discussion was taken on Mr. Garforth's paper, read at a former meeting, "On Working Coal by Long Wall." *(See Part XII., page 302.)*

Mr. WOODWARD said: I think Mr. Garforth protects himself at the commencement of his paper by saying, "To prevent any misunderstanding the writer would like to state that in some mines lying within a few hundred yards of the surface, and in connection with certain natural conditions, there are methods of leaving pillars and getting the coal at two operations, which can be worked to greater advantage than long wall." Of course, in the particular case he is describing, he has a great advantage over the mines in this neighbourhood, in that he is working a perfectly flat mine instead of one dipping perhaps one in 3½. He has a great advantage in many ways. I would like to ask whether his furnace, producing about 156,000 cubic feet of air per minute, is fed by fresh or return air. The question occurs to me whether, under these conditions, namely, issue of gas

and liability to sudden outbursts, it is safe to work with naked lights, even with this quantity of air circulating.

Mr. G. PEACE: It is desirable to know whether the return air is passed over the furnace, as if gas comes off at great pressure, of course its going into the air in its passage through the return might be a source of danger at the furnace.

Mr. WINSTANLEY: I understand Mr. Garforth to mean, that he makes these bore-holes in order to let off the gas, as it comes from the lower mine, gradually; he deals with it by degrees, and so prevents any sudden outburst. Mr. Garforth has adopted this system of tapping the gas at certain distances, which no doubt, by experiment, he has found to be proper distances, in order to prevent the danger which might attend any sudden outburst.

Mr. GARFORTH said that was so.

Mr. DICKINSON: I see that those bore-holes which Mr. Garforth put down are not very deep, only from 4ft. to 16ft.; and he put down from 200 to 300 of them. Now, it is found you have to bore deeper, and holes much further apart than 22 yards—which Mr. Garforth seemed to think necessary—will suffice. There is another remarkable thing about these bore-holes I should like to mention; that is, the pressure of gas coming from the bore-holes put down below the workings only amounts to about as much pressure as the weight of the strata bored through, and does not include the weight of the strata between the surface and the seam. I do not think Mr. Garforth need be under any doubt that there must be some place in the coal in which this gas is accumulated. He says, "it is difficult to comprehend how it can be in a liquid state." If not in a liquid state it must be in a very highly compressed state—it must be so condensed as to be almost liquid.

Mr. BURNETT asked what caused the greatest amount of subsidence—the long wall or the pillar system?

Professor BOYD-DAWKINS: Mr. Dickinson raised a point which struck me as being of very considerable interest. It related to the pressure of the gas. I understood him to say that the pressure of gas in a bore-hole was the pressure of the rock between the top of the bore-hole and the bottom, and not the result of the pressure from the surface down to the workings. I should like to know whether I am right in understanding him to hold that view. With regard to the general question of pressure, I find that the figures, which he quoted from the paper that is before us, would give us for the pressure a depth of something like 1000ft.—a pressure of a column of water 1000ft. deep—which I think would not be very far off the thickness of the rock in which the bore-holes were put—that is to say, the measure from the surface to the bore-holes. That, it seems to me, is an exceedingly interesting theoretical point, and I should be pleased to see it cleared up.

Mr. DICKINSON: Where the pressure is so much reduced, in a bore-hole put down in a mine, is where the intermediate workings have taken off the superincumbent pressure, and only the remaining pressure between the intermediate workings and the bottom of the hole is found to be the pressure of the gas; but that, where the hole is put in horizontally, as Mr. Lindsay Wood put them in, and the whole pressure from the surface was received, then you got the enormous pressure of the whole depth of the coal from the surface.

Mr. GARFORTH: The furnace in the colliery I referred to is fed by 12,000ft. of fresh air, and the return air passes through the dumb drift and up the upcast shaft. As to open lights, we have been working for 20 years with them. By passing a large volume of air, having a long wall face and a sweeping ventilation, we have never felt the want of

lamps. It was not until the intervening strata increased from 4ft. to 16ft.—and prevented the strata from fracturing—that we found the gas was not being given off regularly; we take every means to discover the gas, and the report books show from 20 to 25 feeders per day. When these feeders became reduced it was argued the gas still existed in the lower seam, and the bore-holes showed that it was so. The effect of these bore-holes is gradually to drain off the gas, so that no accumulation is possible. Professor Dawkins mentioned the pressure of a column of water 960ft. deep; that is to say, 320 yards at 1·3lb., which would give 420lbs. of hydrostatic pressure. There is, however, no relation between the pressure mentioned by Mr. Lindsay Wood and the 420 yards which happens to be the depth of the seam. It is an interesting question. Mr. Burnett asked about the subsidence due to pillars as compared with long wall. I think the subsidences take place so gradually—which is shown by the sections made every half year—that there is less damage to the surface by long wall, allowing the land to sink gradually, than by pillar working; and, although I think the total amount of subsidence over a number of years is practically the same, still if you cannot discern any cracks in the property you are not liable to claims for compensation.

Mr. HALL: I should like to ask Mr. Garforth, if he has no objection, to state the name of the colliery, and the locality, where the system of working which he has described is carried on. He tells us that his criterion of where wide work should be adopted in preference to pillar and stall—the test he applies—is the depth the pit is being worked at, but it seems to me that is hardly a test. A better test would perhaps be the nature of the stratification in the neighbourhood, and the seam that has to be worked, because the crush on the roof does not depend on the depth altogether,

it depends also on the nature of the stratification. On reading the paper the same thought struck me that seems to have struck several of the members: it seemed to me a dangerous kind of thing to be using candles in a mine where daily 20 to 25 feeders of gas are reported, and where they had to take the precaution of putting down bore-holes to prevent the gas being given off in large quantities.

Mr. CLIFFORD SMITH: I would like to ask whether there has been any difference found in the pressure of the gas given off, where you have a shallow bore-hole of 4ft. and one of the depth of 16ft. or 18ft.—has any difference whatever been found? Mr. Garforth mentioned that he had sunk a small pit from one seam to the other in one or two places. I should like to know whether any cavity was found between the small seam and the superincumbent strata; or whether, from his experience, gas has been given off direct from the seam to the bore-holes. In certain cases that have come under my notice, where sudden outbursts of gas have occurred, it has accumulated where the various strata have parted, leaving a cavity which has acted as a gas holder; and there has been some fissure or something of the sort that has been opened leading to the seam in working from the cavity, and the outbursts of gas have come from this, and not direct from the coal. Mr. Garforth seems to have tested —if I may so term it—this seam in very many places, and possibly he may say whether he has found in any place any such cavity as I have referred to.

Mr. GARFORTH: That is the whole gist of my paper. It is the cavities that lead to sudden outbursts. Suppose (to reduce it to figures) I take a face 120 yards in length by 40 yards, that is not supposed to have been consolidated. The gas that would accumulate in a cavity half an inch thick, over that area, would be about 1,815 cubic feet. In the pit I sunk—and it was made in order to test the point raised—

I found I was able to put in a piece of wood of a certain thickness, which showed me a cavity existed which would contain somewhere about the quantity of gas stated in my paper. In some pits in South Yorkshire, where the system of working is different from that of Lancashire, and very different from long wall, I consider the outbursts have generally arisen from these cavities; and if you take ten acres (which is not too much to take) as the probable area, you will find the quantity of gas held in one of these cavities is sufficient to overpower the best ventilated colliery.

Mr. CLIFFORD SMITH: I do not think Mr. Garforth has answered my question as to whether he has found any difference of pressure of gas in proportion to depth of bore-hole.

Mr. GARFORTH: Testing with the ordinary water gauge I was surprised to find (although the flame was 4ft. long before the gauge was applied) the gas did not move the water at all. But it passed through the water and fired outside the U tube of the water guage. I have therefore been unable to detect any difference in the pressure of the intervening strata between the 4ft. and the 16ft. bore-holes, and I account for this by supposing the resistance, caused by the gas having to force itself against a column of water even a quarter of an inch, sends the gas up another hole.

Mr. BURROWS: Mr. Garforth told us how he looks after the floor of the mine—the precautions taken to prevent accumulations of gas—but it seems to me he has neglected the roof entirely. It seems to me there is more likelihood of an accumulation of gas in cavities of the roof than in the floor, in ordinary circumstances. If, then, there should be a fall in the waste and a crack or break in the roof leading into such a cavity, you have all the materials for an explosion at once, where naked lights are in use. Such a case has happened, as we all know. We work, as it

happens, exactly on the same plan that Mr. Garforth does—half end and face—and we pack very much as he has described; the stalls also are about the same size; and all the gas we find is in the roof, wherever a little metal falls, forming a hole in the roof, and you cannot get the air right on to it, there a little gas is to be found. This roof, I believe, makes more gas than most; but there we find it continually. We put three bore-holes down to the coal below and found a very little gas at first, but afterwards none.

Mr. GARFORTH: Before the bore-holes were put down, when there was not sufficient dirt to fill the wastes, we occasionally had fires in the goaf; gas accumulated, always coming from the floor and finding its way to the return. But these fires we have not had for a long time. I think, had there been materials for an explosion, they would have revealed themselves.

Mr. WINSTANLEY asked if the fires were due to spontaneous combustion.

Mr. GARFORTH: No; they were due to the gas coming from the floor. Before we put these bore-holes down, the superincumbent weight broke the strata, and allowed the gas to be given off and lighted.

Mr. WINSTANLEY: But how was it lit?

Mr. GARFORTH: It was lit at one of the return air-ways by an open light. Now the gas finds its way up to the bore-holes, where it can be safely dealt with, and we never have a gob fire.

Mr. WINSTANLEY: In mining on the long-wall system, pack how you will a weight comes on, and there are cracks, allowing the escape of gas which will show a cap in the lamp. At the same time, and in the same mine, I have found gas exuding both from the floor and the roof.

ACCIDENTS IN MINES AND THEIR PREVENTION.

By J. S. Burrows, M.E.

PART II.

In opening the discussion upon Mr. Burrows's paper, read at a former meeting, *(see Part XIII., page 336,)*

Mr. Dickinson said: Mr. Burrows, in this paper, states a great many facts, and draws many deductions which require little, if any, discussion. But there is one point, on page 336, which I should like to ask him about, where he describes as necessary "the provision by the owners of the best kind of safety lamp, to be the property of the owners, and used without payment by the men." I should like if Mr. Burrows would give us some further information as to whether he means that the owners are not only to provide the lamps, but also the maintenance of them—that is, the oil—and keeping them in repair; also whether he has duly considered the care that has been taken of the lamps on the part of the men, and what is the best means of insuring that the men will take care of the lamps when they belong to other persons than themselves.

Mr. Burrows: In my paper of course I never touched upon the money part of the question at all; I have gone more for the theory. I believe that the lamps ought to be entirely the property of the owners, but as to maintenance I should not like to lay down any hard and fast rule that they should accept the whole of the cost. It would rather be a matter of arrangement with the men. What I mean to say is that, in my opinion, the lamps themselves and all the dealings with them should be under the eye of the owners. The men should come for them in the morning, take them away lit, bring them back at night, and have nothing more to do

with them. As to the care of lamps by the men, I have known men, after they have left us, go to other pits where they have had to find their own lamps, and I have no hesitation in saying that the lamps they have bought—often discarded lamps obtained at some second-hand dealers, or out of the pawnshop—have been totally unfit for use. As to the care taken of them, what should make the men any more careful of their own lamps than of their employers' ? A man who damages a lamp of ours is responsible for it. If he has a lamp of his own which he injures he may get it repaired at a cost perhaps of 8d., but if he damages ours he is heavily fined. It touches his pocket all the same. But I object entirely to the principle of letting the men have anything to do with their lamps.

The PRESIDENT: It is your view that the lamps should be delivered to the men—actually put into their hands—for working, and seen by the owners of the mine that they are delivered, and that when they come back they should be inspected, and every man who brings in a damaged lamp punished.

Mr. BURROWS: Certainly.

The PRESIDENT: In that case the only question is whether, in the present state of the labour market, you can enforce it.

Mr. BURROWS: Our experience proves that it can, and I must say it is very seldom that we find a lamp damaged.

Mr. HALL: The second part of Mr. Burrows's paper is only what you could expect from the quality of the first. I think it is excellent. But there are one or two matters on which the conclusions he comes to are, I think, rather open to doubt. The first is with regard to timbering. His conclusion is that it is better for the men to timber their own working places—that "there is nothing in either arguments or facts to prove that it would be better to have

skilled persons to do the timbering of the mines, instead of the workmen." Well, as far as argument goes, I do not think Mr. Burrows can doubt that one whose special work it has been to timber all his life will be more skilled in the work than one who is only timbering a part of his time. If you have a man specially trained to timbering he naturally gets skilful, and that man's skill, if he is supervising the men engaged in this work, benefits it may be ten or a dozen working places in the mine, whereas when the men timber themselves each one has to learn by his own particular experience. The deputy who does the timbering, in some districts, not only learns by constant practice, but he learns also by seeing accidents in the different working places, so that he is able to meet difficulties when they arise. The ordinary workman knows nothing of accidents except those which may happen to himself. Then, with regard to statistics, I think statistics prove that it is better to have skilled men to do the timbering, because where they have skilled men—take Durham and Northumberland for instance—in those districts as compared with Lancashire the proportion of accidents is as 3 is to 5. Further on Mr. Burrows, by some method I do not quite understand, reduces it from 3 to 5 to 3 to 4; but, even then, that fact is a strong one in evidence of the superiority of the system which is adopted in the North. With regard to inspection by workmen, there is a rule in the Act of Parliament which says the workmen may inspect at the end of each month; that, Mr. Burrows thinks, will be an advantage. I do not agree with him. I think it would do harm. The proper persons to inspect a mine are those who have the power to enforce what they may require done; and to my mind, if you get workmen to inspect a mine you only substitute an unskilled inspection for a skilled inspection. Mr. Burrows also says that he does not think the workmen who inspect

mines will be placed in any invidious position; but I think they will, not perhaps with respect to the manager, but with respect to the under officials. If any complaint is made they will probably find their position a very uncomfortable one. Then, as to the question of lamps. Recently I have taken out some statistics as to the number of glass lamps and the number of Davy lamps that have got damaged down in mines, and I find that, in a mine working about 500 Davy lamps there is about one damaged in a month, or in two months, in some mines; in others one in three months; whereas in mines where they use glass lamps as many as five are damaged in a day among 500. That being so, it seems to me we are a long way off a safe lamp, and it is very questionable whether we are not advancing in the wrong direction.

Mr. WOODWARD: The point raised by Mr. Hall with reference to safety lamps is, to my mind, a very interesting one. I would like to know in what particular way the glass lamps are damaged; also whether the glass is protected by an asbestos ring at the top and bottom, because we find, as a rule, that the glass is broken by the expansion due to heat, and not so much through carelessness. A glass lamp is seldom broken by violence unless a man drops it on something hard; and we find that, whereas formerly we had many breakages, now, when the glass is protected by an asbestos ring, there are scarcely any.

Mr. WINSTANLEY: I have been watching that point with regard to the damage to safety lamps and glass lamps for some time, and I find that they are damaged, as a rule, by the drawers and waggoners, not by the colliers. I put the question to an underlooker how, in his experience, the lamps were most damaged. The man took a lamp and hung it against a tub to show me the position in which they were often fixed, and he said that a great many lamps were

broken, (when they were so hung,) by other drawers driving waggons full tilt against them. Perhaps a glass lamp would be more easily broken in that way than a gauze lamp. I fail to see myself why a glass lamp, like the Mueseler or Marsaut, should be damaged any more by a collier than a Davy in a working place. An experienced collier is supposed to have his lamp as far back from the face as to place it outside the swing of his pick; and when he is working, as a rule his lamp is never moved except when he takes it up to trim it or something of that sort. I think the great difficulty is to provide a lamp suitable for waggoners and drawers, the greatest damage being caused by them.

The PRESIDENT: The asbestos ring, I suppose, allows for a certain amount of expansion, and so prevents cracking.

Mr. WINSTANLEY: That is so. I do not remember a single case of a lamp breaking by expansion where it has been provided with the asbestos ring.

Mr. HALL: I found, in making these inquiries, that the principal damage was from chips in the tops of the glass, caused either by too tight screwing up or by expansion after the lamp had begun to get hot. That is the great danger, it seems to me, because if the chipping takes place from heat, the chances are it will take place when the man first enters his working place. He may know nothing of it, and work with it all day. With the much-abused Davy lamp if it got damaged it was either by a pick, or by something falling on it; and the man had a chance of knowing when it occurred and of remedying the mischief. Where damage to the glass is caused by expansion through heat the man is perfectly helpless.

Mr. BURNETT observed that the remarks of the last speaker seemed to raise the question of whether there was

any safety in lamps. The Society, he suggested, would do well to lend its influence in having this question fully inquired into.

Mr. WINSTANLEY asked Mr. Hall if the glass lamps he had referred to, which had broken, were provided with asbestos rings at the top and bottom of the glass.

Mr. HALL: Yes; that was particularly brought under my notice. There was an asbestos ring at the top and one at the bottom.

Mr. WINSTANLEY: Glasses have been sold in this country of Belgian and German manufacture. These have been of inferior quality. I know a case in which there was a very narrow escape from a serious accident in consequence of the snapping of the glass in a lamp; but I am told by manufacturers of good lamps that that need not occur if the glass is properly annealed. Many glasses break through not being properly manufactured.

The PRESIDENT: They are too brittle, I suppose?

Mr. WINSTANLEY: They are.

Mr. MARTIN: If I understood Mr. Burrows correctly, it was the Davy lamp, he referred to as being out of pattern. I should like to know his experience as to what number of lamps a man can clean carefully, examine thoroughly, and put out of hand in a perfect state during a shift? With shields on the lamps, it will be necessary for the lamp man to be even more careful than formerly in his examination of them, as there is less opportunity of checking him. With regard to glasses, as Mr. Winstanley very properly remarked there is great difference in the quality. For a long time, when I was on the Continent, we got our glasses from England, in consequence of those of local manufacture being so brittle. Among the 600 or 700 lamps at work, 60 glasses in a month would be about the average number that were

broken or injured. In many cases they were only cracked from expansion; and many people would not consider a glass so cracked defective. The damage to lamps by being bumped on the waggons may be reduced, as for example, when a Mueseler is used for drawing with it is usually carried by the waggoner suspended on his thumb, not hung upon the tub itself. Hanging lamps on the tub is undesirable. Naturally, where there are more pieces in a lamp there is greater necessity for careful supervision; and I can quite understand that unless the management is very strict in enforcing upon lamp cleaners the necessity for such examination, &c., they may be sent out in an improper state. If a man has only a certain number to look after, and not more than he can do well in a regular shift, I see no reason why a lamp should be sent out in an unfit state. The question as to the cost to be charged for maintenance—whether 3d. or 4d. per week—seems a matter between the men and the masters; I do not think it has anything to do with the question of the safety of the lamp. Mr. Burrows, in his paper, says that a travelling road, separate from the jig roads, would obviate accidents. On the Continent it was the law that there should be a separate travelling road. Persons were not allowed to travel in the jigs. As to the system of timbering by deputies as in the North of England or by the colliers, as in Lancashire, the efficiency depends much upon the circumstances of the case. I think, in some cases, if the men were not obliged to set the timber for their own safety, there would be rather more danger. In my own case I had 26 deputies setting timber and going round the places, but we had to enforce the setting of the timber by the men very largely for their own safety. In reference to falls, slips, dip, thickness, nature of roof and floor, &c., they vary so much in seams that even in the same colliery, under the same management, there can be no fair comparison made between them.

In the collieries which I had charge of there were entirely different circumstances in the several seams. One had a roof that would stand almost without any timber; another had a very bad roof; another had the floor bad; and some had both. We had 3½ to 4ft. and 6ft. seams from nearly level to a dip of 20°, and also 6 and 9ft. seams standing at angles of 35° to 60°. The circumstances, therefore, require great consideration in making comparisons.

Mr. BURROWS: Mr. Martin asked how many lamps could be cleaned by a lamp man in a single shift. I do not know that I can answer that question off-hand; a great deal would depend on the make of the lamp—how much screwing and unscrewing there would be—and what amount of cleaning it would require. Where the Mueseler is used three men can clean and completely examine over 300 lamps in the 12 hours. The lamps are often pulled to pieces and tested by the firemen at the pit bottom. The lamps so tested are taken at random; the lamp cleaners do not know which may be overhauled; and I must say we have had no complaints yet. Then a question has been raised about damaged glasses. Of course it is the fact that there are many cracked; but I can only recollect one out of all our lamps that has been chipped through; as a rule there is simply a crack much less in its dimensions than the mesh of the gauze, and therefore not necessarily a source of danger. I should not, however, advocate the use of a lamp in that state. As soon as the defect is seen the glass ought to be changed. Still I should not have the least hesitation in testing for gas with a lamp with a cracked glass if it was simply a crack. As to deputies being more skilled in timbering, no doubt what Mr. Hall says is true, that where men are constantly propping they got more skilful. That, however, would be of little avail unless a deputy was always at hand. My contention is this—looking at the practical

working of the thing, where a mine has a bad roof, full of slips and joints which are laid bare without a moment's warning—if the men were taught to rely on the deputies setting their timber, whatever risks they may run now they would run many more then. As to workmen's inspection, Mr. Hall seems to take me to mean that workmen should inspect and nobody else. I did not mean any such thing. I have no objection to as much government inspection as you like; there should be an inspection by workmen in addition. Let the men conscientiously exercise their power. I have seen it done in Durham many a time, and I have not known any evil results from it. Personally I should always be pleased to see the workmen, and should offer them all the facilities that have been given to Her Majesty's inspectors lately.

Mr. DICKINSON: This inspection by workmen, when it was introduced into the bill which became law, I looked upon as a most important concession to the miners; and the experience now of about 13 years under that rule makes me prize it more and more. The only matter for regret is that the men so seldom exercise the privilege. At a recent inquest which I attended, the jury deliberated for a long time, and could not come to the conclusion whether they should recommend the Government to make it compulsory, so much impressed were they with the advantage of inspection by the men on their own behalf.

Mr. MCADOO mentioned that in certain collieries in Durham both lamps and oil are found by the masters. In the mine where he was brought up no one was ever allowed to use a glass lamp for waggoning. The lamps were hung at short distances along the waggon road, and the waggoners were prohibited from touching them. In that way there was no fear of their getting damaged in the way that had been described.

excite no wonder, seeing the close relationship claimed for it to the *Lepidodendra*, which possess that habit in a high degree.

About 6ft. below the last-mentioned dark shale is a 9in. coal, covered by a 2in. band of black shale containing fish remains; and overlaying the shale is a dark-blue soap-stone bearing shells (*Anthracosia*), and in the grey seat below the coals, *Stigmaria* are abundant and good, and pass downwards through no less than 9ft. of strata, consisting of four distinct layers or beds of rock and strong shale. In one bed of rock are found some very strange rootlets, very well preserved specimens of which are on the table, and also shown on the small sketch in black. Specimens of stigmarian rootlets with which they were associated are also laid on the table for comparison; but whether the former be stigmarian rootlets bifurcating, or the roots or stems of some other plant with that habit, I am not prepared to give an opinion, further than that in appearance they differ very little indeed from the true rootlets of *Stigmaria*, either in the central ridge supposed to be owing to the character of the central vascular bundle, so well known in those rootlets, or the size and form of those found in the same bed of rock and in close proximity. *Ferns*, *Calamites*, *Pinnularia*, &c., are found immediately below this seat.

At 67 yards below the New Mine is found a 5in. coal on which rests a bed of blue shale, bearing *Calamites*, and under it a seat with abundance of *Stigmaria*. At 74 yards we come upon a 5½in. coal, with a roof of black shale, containing some very fine specimens of *Anthracosia robusta*, and a few rather indistinct shells *(Modiola)*, specimens of which are on the table, and about 18in. above these shells lies the cleanest bed of flaggy and slaty micaceous sandstone in the whole sinking. The perpendicular joints are filled with beautiful crystals of carbonate of lime, and the thick-

practised eye is accustomed, in the recognition of a coal seat, are due to the presence and past action of the once hungry roots and rootlets known as *Stigmaria*.

There are many other palæontological characteristics which, if not strictly persistent, are sufficiently so in very many cases, to greatly assist the mining engineer when groping his way in faulty ground, or piercing perpendicularly the strata in neighbouring but imperfectly known estates, whilst the facilities possessed by those engaged in such pursuits, for assisting scientific study, are such, that it could not fail to be a national benefit if more attention on the part of those so favourably circumstanced were devoted to the subject.

The section* sunk through at Bardsley proved an interesting one to the writer, being for the most part in measures to which he was practically a stranger, that cause being sufficient to create the zest with which the various litho-logical changes, as well as the nature of the fossil forms contained therein, were eagerly watched. There was nothing calling for particular attention in the measures from the old mine at 545 yards until reaching the roof of the new mine at 562 yards. The dip agreed with the general run of the measures in the estate, whose direction is a few degrees east of south, and inclination nearly 5 degrees, or about 1 in 12. The roof, however, of the new mine contains two beds of *Anthracosia*, one about 3ft. and the other 15in. above the coal. The shells differ slightly in form and size, but may be the same species in a different stage of growth, or if fully developed probably dissimilarly circumstanced.

The coal itself exhibits one of those phenomena out of many that puzzle the geological student. The upper layer is an inferior band of shaly coal, 6in. thick, in thin folds, looking bright in the face of a working place, but dull

* See detailed section, page 456.

from the stratum of grey leys before-mentioned. Fig. C is a shale specimen from Ashton Moss Colliery, and Fig. D

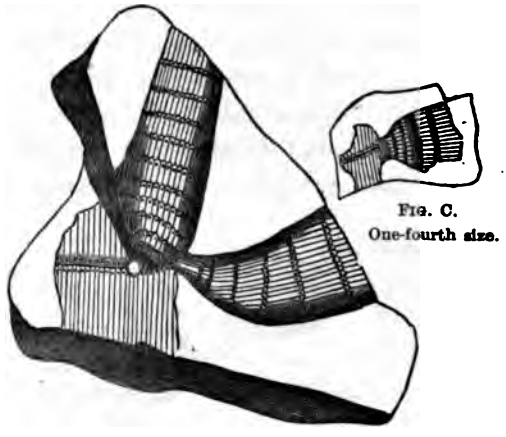


FIG. C.
One-fourth size.

FIG. D.—One-fourth natural size.

is a good specimen of a rhizome, giving off two shoots at a node. This was obtained from Limehurst Colliery in strata overlaying the Black Mine. Figs. E and F represent

FIG. E.—Half-size.

FIG. F.—One-fourth natural size.

specimens in my cabinet showing what I take to be aerial branches of *Calamites*, found at Bardsley Colliery below the Peacock Mine. The specimens seemed to throw off such

shoots at every node, whilst the nodes were about 6in. apart, and fragments of *Pinnularia* were plentifully strewn about the specimens.

From a study of the modes of growth of the *Equisetum* (horse-tail family) of the present day, I feel persuaded that a very close relationship, in habits of growth especially, must be allowed for the calamites found in the rocks and shales of the coal measures. A subterranean rhizome, giving off shoots singly or in pairs at the nodes, which become aerial stems throwing off verticils of branches, their bases whilst subterranean giving off other stems at about the third to the sixth node from the point of articulation, which again may give rise to shoots from the newly-formed nodes or joints remaining underground, in the same order and manner. During the growth of the plant these nodes and bases of branches, if such they may be termed, are embedded in the earth or mud in which the plant has taken root; and thus, though the articulated end of the shoot seems to have had but a very slender attachment to the parent rhizome, it seems quite sufficient, under the circumstances, for the support of the stem, assisted as it was by verticils of roots from the underground nodes.

It has puzzled many to see the stout conical bases, called terminals by authors (and in fact figured years ago as tops of calamites), supported by so weak a connection. Yet from these specimens it seems evident that they were the underground bases, supported, as far as was necessary and natural, by the soil in which they grew.

That the *Calamites* of the palæozoic period were giant *Equiseta* compared with those of the present day is seen by the fact that Professors Williamson and Dawkins measured one to which I drew their attention in the roof of a coal mine about two years ago, 30ft. in length, without terminating

in either direction, and which contained nearly 200 nodes, a few of which seemed to have given off verticils of branches. The taper of the flattened stem was from 6in. at the large end to 4⅛in. at the small end, and the approximation of the nodes from 3in. to ¼in., whilst we should consider 5ft. to 6ft. to be tall for the growth of an *Equisetum* in this country. Though from a careful examination into the internal structure of the *Calamites* as compared with the present *Equisetum* we find a great many points of similitude, my imperfect knowledge of botany will not enable me to do justice to the subject of comparison.

At 646 yards deep, or 84 yards below the New Mine, we pass through an inferior coal 7in. in thickness, overlaid by a bed of shale, at the bottom of which, laying on the coal, are found fish remains, and at 1ft. 2in. below the coal is a band of impure cannel also bearing fish remains through its whole thickness, which is only 8in. I am not aware of any generally accepted hypothesis having been promulgated, for the presence, in very many cases, of fish remains immediately on the tops of coal seams—a subject which seems to me to possess rather more than ordinary interest.

At 115 yards we find a coaly bass 1½in. thick, on the top of which is a dark raggy rock band about 1ft. thick, overlaid by a 20in. bed of micaceous shale containing fish remains scantily, with the dermal tubercles or shagreen of some selachian or shark-like fish. Over this is a black shale, and, resting on that, are beds of soapstone and ironstone alternating, in the manner common to the measures a short distance above the Arley or Royley Mine in most districts. These measures are again succeeded in descending order by beds of brown and white rock, followed by the dark blue metal and ironstone bands usually overlaying the Royley Mine. In these bands of dark blue metal or non-micaceous shale were found a few good specimens of dichotomizing

twigs of *Lepidodendron*, one of which has the pendulous fruit or *Lepidostrobus* still attached.

We next pass through nearly 9 yards of laminated dark grey arenaceous shale alternating with dark bands of sandstone, and reach the Royley Mine at nearly 140 yards below the New Mine, or about 702 yards from the surface. There is a marked change in the roof, or more properly speaking, the inferior top coal and shale which usually overlies the workable portion of this mine in the Oldham district. The hard rock bands are found immediately on the soft mining coal, which is about the usual thickness of 4½ to 6in. except where thinned by the sandstone band, which is a very irregular one, lying in flakes or patches, and displaying unconformable beddings at an angle of about 45 degrees from the true stratification of the coal and overlying measures. The rock band itself is a very dirty-looking one, containing iron pyrites, and the flow of the material forming this false-bedded sandstone seems to have been from east to west, as the lines of stratification have an upward inclination when crossing them in a westerly direction. The lower portion of the seam bears the prevailing character of the Royley Mine in the adjoining districts, as also does the floor or seat. The coal itself, although containing layers of soft charcoal, "rotten coal" of some districts, is good and clean, though rather soft, and perhaps too thin to tempt any one to venture to work it at that depth at the present day.

from the stratum of grey leys before-mentioned. Fig. C is a shale specimen from Ashton Moss Colliery, and Fig. D

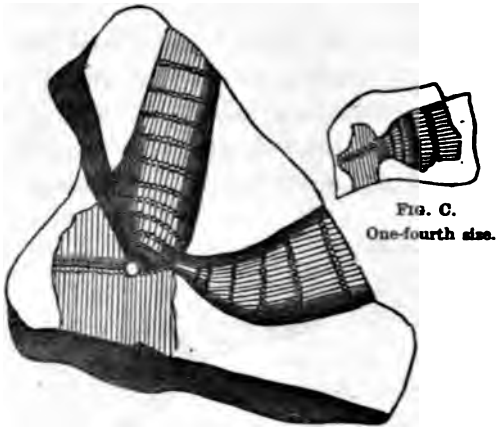


FIG. C.
One-fourth size.

FIG. D.—One-fourth natural size.

is a good specimen of a rhizome, giving off two shoots at a node. This was obtained from Limehurst Colliery in strata overlaying the Black Mine. Figs. E and F represent

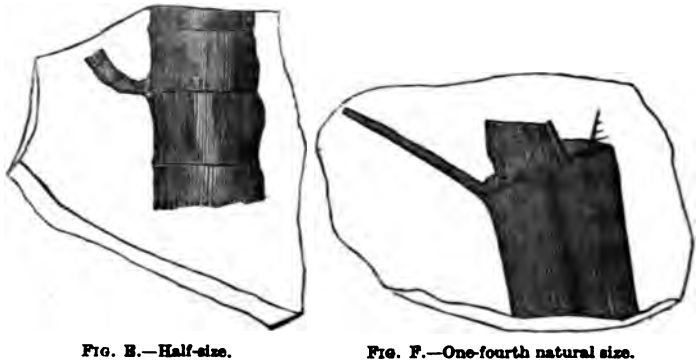


FIG. E.—Half-size.

FIG. F.—One-fourth natural size.

specimens in my cabinet showing what I take to be aerial branches of *Calamites*, found at Bardsley Colliery below the Peacock Mine. The specimens seemed to throw off such

shoots at every node, whilst the nodes were about 6in. apart, and fragments of *Pinnularia* were plentifully strewn about the specimens.

From a study of the modes of growth of the *Equisetum* (horse-tail family) of the present day, I feel persuaded that a very close relationship, in habits of growth especially, must be allowed for the calamites found in the rocks and shales of the coal measures. A subterranean rhizome, giving off shoots singly or in pairs at the nodes, which become aerial stems throwing off verticils of branches, their bases whilst subterranean giving off other stems at about the third to the sixth node from the point of articulation, which again may give rise to shoots from the newly-formed nodes or joints remaining underground, in the same order and manner. During the growth of the plant these nodes and bases of branches, if such they may be termed, are embedded in the earth or mud in which the plant has taken root; and thus, though the articulated end of the shoot seems to have had but a very slender attachment to the parent rhizome, it seems quite sufficient, under the circumstances, for the support of the stem, assisted as it was by verticils of roots from the underground nodes.

It has puzzled many to see the stout conical bases, called terminals by authors (and in fact figured years ago as tops of calamites), supported by so weak a connection. Yet from these specimens it seems evident that they were the underground bases, supported, as far as was necessary and natural, by the soil in which they grew.

That the *Calamites* of the palæozoic period were giant *Equiseta* compared with those of the present day is seen by the fact that Professors Williamson and Dawkins measured one to which I drew their attention in the roof of a coal mine about two years ago, 30ft. in length, without terminating

in either direction, and which contained nearly 200 nodes, a few of which seemed to have given off verticils of branches. The taper of the flattened stem was from 6in. at the large end to 4⅛in. at the small end, and the approximation of the nodes from 3in. to ¼in., whilst we should consider 5ft. to 6ft. to be tall for the growth of an *Equisetum* in this country. Though from a careful examination into the internal structure of the *Calamites* as compared with the present *Equisetum* we find a great many points of similitude, my imperfect knowledge of botany will not enable me to do justice to the subject of comparison.

At 646 yards deep, or 84 yards below the New Mine, we pass through an inferior coal 7in. in thickness, overlaid by a bed of shale, at the bottom of which, laying on the coal, are found fish remains, and at 1ft. 2in. below the coal is a band of impure cannel also bearing fish remains through its whole thickness, which is only 8in. I am not aware of any generally accepted hypothesis having been promulgated, for the presence, in very many cases, of fish remains immediately on the tops of coal seams—a subject which seems to me to possess rather more than ordinary interest.

At 115 yards we find a coaly bass 1½in. thick, on the top of which is a dark raggy rock band about 1ft. thick, overlaid by a 20in. bed of micaceous shale containing fish remains scantily, with the dermal tubercles or shagreen of some selachian or shark-like fish. Over this is a black shale, and, resting on that, are beds of soapstone and ironstone alternating, in the manner common to the measures a short distance above the Arley or Royley Mine in most districts. These measures are again succeeded in descending order by beds of brown and white rock, followed by the dark blue metal and ironstone bands usually overlaying the Royley Mine. In these bands of dark blue metal or non-micaceous shale were found a few good specimens of dichotomizing

22	546	Old Mine	Bing parting	0	0	8	
			Good quality Bottoms	0	2	0	
			Coal and Shale	0	1	0	
			Seat Stone	0	2	0	*Stigmaria.*
			Strong Rag (Gritty) Metal....	4	2	9	*Interspersed with Rock Bands.*
			Ironstone Band	0	0	2	
			Strong Blue Metal.....	4	2	0	
			Soft Blue Metal	4	1	0	*Two beds of Anthracosia found here, one at 15in. and one at 36in. from bottom.*
23	562	New Mine	Top Coal, inferior, slaty	0	0	6	
			Middle Sump Coal, inferior ..	0	0	3	
			Bottom Coal, fair quality	0	1	9	
			Strong Brown Seat Stone	0	1	5	*Strong Brown Stone Seat, highly characteristic of this seam, full of Stigmaria.*
			Strong Grey Seat	0	1	0½	*Rootlets of Stigmaria continue through this stratum.*
			Dark Blue Nodular Seat	0	1	9	*Nodules of ironstone and rootlets permeate this layer.*
			Grey Rock Seat	0	2	0	*The rootlets from the above Stigmaria in some instances penetrate to bottom.*
			Strong Rag	0	1	11	
			Rock Band	0	0	3½	
			Strong Rag	0	1	5½	
			Irregular Rock Band	0	0	3½	*An irregular band of rock (sandstone) is found here.*
			Strong Rag	0	0	10½	
			Very strong White Rock	0	1	0	*This rock is very hard.*
			Grey Leys or Rag Rock	2	1	4½	
			Sandy Ironstone Band	0	0	1½	*A brown dull Arenaceo-Ferruginous band.*
			Blue Metal	1	0	9	
			Ironstone 1in., Soft Shale 2½in.	0	0	3½	
			Blue Shale Ironstone Bands..	0	1	9½	*Good and large Septaria divided internally by thin walls of Carbonate of Lime* ($Ca.OCO^2$)
			Black Shale and Ironstone Nodules	1	0	3½	
			Smut of Coal		....		*A thin smut or parting of coal, a mere film.*
			Strong Brown Rock Seat	0	1	3	*A brown rock seat with very good Stigmaria, an inch of soft brown seat on top.*
			Grey Rock Seat	1	0	4½	*Strong rock seat with rootlets.*

SECTION OF THE STRATA—*Continued.*

No. of Seam.	Depth in Yds. from Surface.	Name of Seam.	General Character of Strata.	Yds.	Ft.	In.	Descriptive Remarks, including Mineralogical and Palæontological characteristics.
			Streaked Grey and Brown Rag	0	1	6	*The most beautiful irregular stratification of grey and brown rag.*
			Slaty White Rock	0	2	4	
			Hard Grey and Brown Rock..	1	1	6	*A layer of dark spherical nodules, containing nothing organic, but very singularly marked in several cases with worm-like wreaths and other additions. This rock is very hard, with occasional patches of vegetable markings.*
			Grey Rock	2	2	7	
			Strong Grey Leys.....	1	2	3	
			Softer Grey Leys	0	2	2	
			Blue Soapstone Ley Bands ..	5	0	3	*Ironstone bands from ½in. to 2in. thick.*
			Black Stone.....	3	1	6	*A few flattened Anthracosia met with.*
			Black and Grey Rag 5in., Smut 1in.	0	0	6	
			White Seat, soft.....	0	1	0	
			Raggy Rock Seat, Dark Bands	1	1	0	*Stigmaria and rootlets.*
			Coarse Grey Leys	1	1	5	
			Fine Grey Leys	2	1	2	
			Blue Metal	1	1	2	
			Coarse Dark Grey Rag.....	0	1	8	
			Dark Grey Leys or Black Stone	1	2	1	
			Blue Soapstone	1	0	0	
			Ironstone	0	0	2	
			Blue Soapstone	0	1	4	
			Ironstone	0	0	3	
			Blue Shale	1	0	8	
			Strong Black Shale	1	1	10	*Temperature of the strata at this point, 69° Fahr.; depth, 1,812 feet from surface.*

			Blue Metal, jointy	0	1	1	
			Blue Metal	1	1	6	
			Strong Blue Metal	3	0	9	*This stratum contains a strange species of Calamite branching in verticillate form (Calamitina ?)*
			Blue Shale	1	0	6	*Good Ferns and a beetle-like insect (?) were found in this shale.*
			Coal and Shale	0	0	5	
			Coal or Shale parting	0	0	4½	
	490	Foot Coal	Coal of very good quality	0	1	0½	*This coal is of very good quality, and gave off much gas (fire-damp).*
			Dark Shale	1	0	0	*Coal plants.*
			Blue Metal and Ironstone	0	2	3	*Ironstone nodules.*
			Black Bass and Bing, or Clod.	0	1	11	*Bastard cannel.*
18	493	Nealy Mine	Inferior Coal in 4 layers, with shale partings	1	0	1	
			Strong Blue Seat	2	0	0	*Stigmaria.*
			Ironstone	0	0	2½	
			Strong Blue Metal	2	2	9½	*Ferns near bottom of this layer of metal.*
			Dark Shale	0	2	3	*Sigillaria, Lepidodendra, &c.*
19	499	Davis Mine	Inferior Coal	0	1	4	
			Strong Blue Seat	0	0	11	*Ferns, &c.*
			Strong Rock Seat	0	2	6	*Stigmaria and rootlets.*
			Blue Metal & Ironstone Band	0	0	5	
			Strong Blue Metal	0	1	10	
			Rag or Gritty Metal	1	2	0	
			Very hard White Rock	0	2	0	
			Rag or Gritty Metal	3	0	6	
			Ironstone Band	0	0	2	*Ironstone.*
			Blue Metal Bands	1	1	4	*Ironstone.*
			Blue Shale	0	1	10	*Band at top.*
	509	Seddon Coal	Inferior Coal	0	0	10	
			Dark Seat	2	0	2	*Stigmaria.*
			Black Rag with Rock Bands	1	0	6	

* These numbers refer to Seams of Coal one foot and upwards in thickness from the surface downwards

SECTION OF THE STRATA—*Continued.*

No. of Seam.	Depth in Yds. from Surface.	Name of Seam.	General Character of Strata.	Yds.	Ft.	In.	Descriptive Remarks, including Mineralogical and Palæontological characteristics.
			Black Shale or Metal.....	1	0	6	
			Ironstone Band	0	0	1½	
			Black Shale and Iron Band..	1	0	1½	
			Black Shale or Stone	0	1	9	
			Coal	0	0	1	
			Bing	0	1	0	
			Coal	0	0	5	*Fish remains scarce.*
			Bing	0	0	1	
20	517	WATER MINE	Coal of fair quality	0	1	10	*The 22in. includes 3in. bottoms, inferior.*
			Soft Shale and Coal	0	0	10	*Stigmaria.*
			Rock Seat changing to Metal and Rock Bands	4	0	2	*Stigmaria.*
			Gritty Metal with Rock Bands	0	1	2	*Kank on top.*
			Rag	2	0	2	
			Blue Metal	0	2	0	
			Black Shale	0	1	7	
21	525	LOWER CANNEL ..	Inferior Cannel		....		*Fish scarce; on the top are found shells Anthracosia.*
			Black Stone	3	0	6	
			Black Shale	0	2	3	*Anthracosia.*
			Black or Dark Shale Coal Floor	1	2	0	
			Brown Shale	0	0	5½	*Fish remains at bottom.*
			Strong Blue Metal	1	2	2	
			Soft Blue Metal	2	0	2	
			Blue Shale	1	1	9	
			Black Bassy Shale	0	2	7½	*Fish remains.*
			Blue Metal	7	1	9	*Some thin bands of ironstone.*
			Black Bing or Clod	0	1	0½	
			Black Bass	0	0	7½	

647	8in. Do. Cannel	Bastard Cannel	0	0	8	*This inferior cannel contains Fish remains, Rhizodus, Megalichthys, Plewrodus, and others in parting, and also internally.*
		Soft Dark Seat	0	2	11	
		Strong Grey Seat	0	1	0	
		Rock Seat	0	1	0	
		Strong Metal and Grey Leys..	5	0	3	
		Dark Shale	0	0	7	*Plant remains.*
		Strong Metal and Grey Leys	7	2	1½	
		Strong Flaggy Rock or Leys..	0	2	0	
		Strong Metal and Grey Leys..	7	0	11	
		Blue Metal with Ironstone Bands	4	2	11½	*These beds or bands are fairly regular.*
		Dark Blue Metal or Shale ..	1	2	4½	*The ironstone is in irregular layers and flattened nodules.*
		Soft Black Shale	0	2	0	*This was clean shale and non-micaceous.*
		Strong Black Shale	0	1	8½	*This was hard black shale, micaceous, with Fish remains, near bottom, like Arley roof, at Burnley.*
		Dark Rag Rock	0	1	0	*This contained plant remains, Ulodendron, Calamite, &c.*
678	1½in. Bass Coal ..	Coaly Bass	0	0	1½	
		Grey Rock (Curly).....	1	0	8	
		White Rock	1	0	9	
		Grey Leys	0	1	5	
		White and Brown Rock	1	0	10	
		Grey Leys	0	1	3	
		Strong Blue Metal	2	0	5	
		Rock Bands and Grey Leys ..	0	1	6½	
		Blue Metal with Ironstone ..	3	0	9½	*These bands lie in patches.*
		Dark Blue Metal or Shale, with Ironstone	4	1	6	*These bands of Ironstone are slightly arenaceous.*
		Dark Slaty Rag or Grey Leys and Rock Bands ..	8	2	5	*In this slaty rag was found Lepidodendron, with a twig bearing a Lepidostrobus (fruit).*
						The tops and shale common to Oldham (Royley) are wanting in this shaft.
702	Royley Mine	Mining Coal.....	0	0	6	*This mining coal is soft and dull-looking, but clean.*
		Bottom Coal	0	2	1½	*This bottom coal is bright and very clean and good.*
		Dark Blue Seat		....		

SECTION OF THE STRATA—*Continued.*

No. of Seam.	Depth in Yds. from Surface.	Name of Seam.	General Character of Strata.	Yds.	Ft.	In.	Descriptive Remarks, including Mineralogical and Palæontological characteristics.
			Streaked Grey and Brown Rag	0	1	6	*The most beautiful irregular stratification of grey and brown rag.*
			Slaty White Rock	0	2	4	
			Hard Grey and Brown Rock..	1	1	6	*A layer of dark spherical nodules, containing nothing organic, but very singularly marked in several cases with worm-like wreaths and other additions. This rock is very hard, with occasional patches of vegetable markings.*
			Grey Rock	2	2	7	
			Strong Grey Leys.....	1	2	3	
			Softer Grey Leys	0	2	2	
			Blue Soapstone Ley Bands ..	5	0	3	*Ironstone bands from ½in. to 2in. thick.*
			Black Stone.....	3	1	6	*A few flattened Anthracosia met with.*
			Black and Grey Rag 5in., Smut 1in.	0	0	6	
			White Seat, soft.....	0	1	0	
			Raggy Rock Seat, Dark Bands	1	1	0	*Stigmaria and rootlets.*
			Coarse Grey Leys	1	1	5	
			Fine Grey Leys	2	1	2	
			Blue Metal	1	1	2	
			Coarse Dark Grey Rag	0	1	8	
			Dark Grey Leys or Black Stone	1	2	1	
			Blue Soapstone	1	0	0	
			Ironstone	0	0	2	
			Blue Soapstone	0	1	4	
			Ironstone	0	0	3	
			Blue Shale	1	0	8	
			Strong Black Shale	1	1	10	*Temperature of the strata at this point, 69° Fahr.; depth, 1,812 feet from surface.*

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XVIII. SESSION 1885-6.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, March 2nd, 1886, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

The President, H. M. ORMEROD, Esq., F.G.S., in the Chair.

HONORARY MEMBER.

Professor W. C. WILLIAMSON, LL.D., F.R.S., having been previously recommended by the Council for election as honorary member, was now balloted for, and unanimously elected, an honorary member of the Society.

ORDINARY MEMBERS.

The following gentlemen were elected ordinary members of the Society:—

Mr. WM. CLIFFORD, M.E., Norton Woodseats, Sheffield.

Mr. ROBERT KNOWLES, Arncliffe, Cheetham Hill.

THE BRITISH ASSOCIATION MEETING, 1885.

The PRESIDENT stated that last year, Mr. Stirrup, one of the Honorary Secretaries, was appointed to represent the Society at the meeting of the British Association at Aberdeen. Mr. Stirrup had prepared, at the request of the Council, a short report for presentation to the Society, which he would read.

Mr. STIRRUP stated that the Report was ready for presentation to the February meeting, but the crowded nature of the programme for that day prevented it being read, and other duties had prevented him from an earlier preparation of it.

REPORT TO THE COUNCIL.

BY MARK STIRRUP, F.G.S.,

Delegate to the Meeting of the British Association at Aberdeen, Sept., 1885.

The Manchester Geological Society having been elected as one of the Corresponding Societies of the British Association, at the meeting in Aberdeen, in September last, and your President not being able to attend, I was appointed to act as your delegate on that occasion.

Having previously reported orally to the Council the results of the Conference of Delegates, and as much uncertainty and ignorance exist (even among the delegates themselves) as to the functions of the delegates, I have been requested to draw up a short report of what was done at Aberdeen, and to state the object of the appointment of Corresponding Societies of the British Association. To do this, it will be necessary to give a short sketch of the history of the movement which resulted in the formation of a special committee of the British Association, called the Corresponding Societies' Committee.

There is, as you are well aware, a multitude of scientific associations or societies, scattered over the length and breadth of

the land, of which many are established in the towns and cities visited by the British Association.

Several of these societies take high rank in their own neighbourhood, and are the sources from which spring important local investigations pertaining to its special products or resources; such as those relating to the mineral wealth or the geology of the district, the nature of the fauna and flora, and all matters connected with the local history or archæology. Many of them publish Proceedings or Transactions, which record local researches and isolated facts of wide interest, which are often lost to science or to fellow-workers in other districts. It was with a view of gathering together or concentrating the diffused work and individual efforts of these local scientific societies that preliminary steps were taken some few years ago by a few independent members of the British Associations to ask the Council of that institution to aid and assist them in the attempt to organize and utilize this dispersed scientific energy. The outcome of the application and subsequent Conference was the appointment of a Local Scientific Societies' Committee to consider the matter and to prepare a report for presentation to the Council.

This Report came before the General Committee at the meeting of the Association at Southport in 1883 (*vide* Ann. Rep. Brit. Ass., 1883, p. 318), and was referred to the Council accompanied by the following resolution:—"That the Council be empowered to appoint a Committee, as recommended in their Report adopted by the General Committee on August 23, in order to draw up suggestions upon methods of more systematic observation and plans of operation for local societies, together with a more uniform mode of publication of the results of their work. It is recommended that this Committee should draw up a list of Local Societies which publish their proceedings."

This list was prepared (and was mainly due to the labours of Mr. H. G. Fordham) and is published with the above mentioned Report for 1883.

This report also contains a number of suggested new rules relative to corresponding societies.

These proposed new rules were considered, adopted, and passed

by the General Committee in 1884, and they now form part of the established code of rules of the Association.

The purport of the rules and the object which the Corresponding Societies Committee has in view will perhaps be most succinctly conveyed by the circular which was sent to the local societies from the office of the British Association in March, 1885.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,
22, Albemarle Street, London, W.

March 25, 1885.

Sir,—On behalf of the recently-appointed Corresponding Societies Committee of this Association we desire to call the attention of your Society to certain Rules of the Association adopted at the meeting of the General Committee in November last.

You are no doubt aware that during the last few years the subject of the relation of Local Scientific Societies to the British Association has received considerable attention, and that an opinion has been strongly expressed that the Local Scientific Societies and the British Association might, without any considerable sacrifice of independence, usefully co-operate in facilitating the conduct of investigations into local phenomena such as are frequently undertaken by Committees of the Association.

With this purpose in view the Rules, of which we annex a copy, have been prepared, and have now been finally adopted by the General Committee of the Association; and under their provisions a Corresponding Societies Committee has been appointed.

We have to point out that by these Rules certain advantages are accorded to those Societies which may become Corresponding Societies of the Association. A list of the papers and contributions to science of a local character published by them will appear annually in the Report of the Association. They will be entitled to be represented in the governing body of the British Association (the General Committee), and their Delegates will together constitute an Annual Conference, at which matters affecting the Societies, and the methods by which they may be able to assist the Committees of the Association in the investigations entrusted to them, will be discussed.

On the other hand, it will be required of the Corresponding Societies that they shall make an annual return of the scientific work they have accomplished, for the information of the Corresponding Societies Committee.

We have to ask that you will lay this letter and the annexed Rules before your Society, and, should the Society desire to be enrolled as a Corresponding Society of this Association, we shall be obliged if you will, before the date fixed by the Rules (June 1), return the enclosed Form of Application, with

the Schedule duly filled up, and with specimens of the publications of the results of the local scientific investigations recently undertaken by the Society, addressed to the Secretary of the Corresponding Societies Committee, from whom any further information you desire may be obtained.

We are, your obedient servants,

RAYLEIGH, *President.*
A. W. WILLIAMSON, *General Treasurer.*
DOUGLAS GALTON, }
A. G. VERNON-HARCOURT, } *General Secretaries.*
T. G. BONNEY, *Secretary.*

In the initiatory steps of a movement such as this much can not be expected, seeing that most of the delegates are often unknown to each other, and imperfectly informed as to what is to be done. Moreover, during the short time reserved for the conferences of delegates amid the crowded hours of a British Association meeting little can be hoped for, unless the delegates come prepared to discuss some definite plan or object.

The first conference of delegates convened under the new rules took place on the 10th September, 1885, at Aberdeen, when some informal discussion took place as to the mode and character of the work which could best be undertaken by local scientific societies.

The Chairman (Mr. Francis Galton, F.R.S.), explained that it was not the business of the conference to suggest or initiate any scheme of local investigation. Proposals of this kind must go through the ordinary channel and be considered on their merits by the General Committee; but primarily, any new proposal must have the sanction and approval of the section to which the subject belonged.

In the absence of any new proposals thus ratified, it was for the meeting to discuss how schemes of the kind now in operation, and previously sanctioned by Committees of the British Association could best be aided and completed.

Various inquiries and systematic researches, as it is well known, are carried on from time to time both at home and abroad under the control of Committees, to whom grants in aid are made.

The reports of these Committees form the most valuable portion of the annual volume of the Association.

Committees such as those appointed for the purpose of in-

THE BRITISH ASSOCIATION MEETING, 1885.

The PRESIDENT stated that last year, Mr. Stirrup, one of the Honorary Secretaries, was appointed to represent the Society at the meeting of the British Association at Aberdeen. Mr. Stirrup had prepared, at the request of the Council, a short report for presentation to the Society, which he would read.

Mr. STIRRUP stated that the Report was ready for presentation to the February meeting, but the crowded nature of the programme for that day prevented it being read, and other duties had prevented him from an earlier preparation of it.

REPORT TO THE COUNCIL.

BY MARK STIRRUP, F.G.S.,

Delegate to the Meeting of the British Association at Aberdeen, Sept., 1885.

The Manchester Geological Society having been elected as one of the Corresponding Societies of the British Association, at the meeting in Aberdeen, in September last, and your President not being able to attend, I was appointed to act as your delegate on that occasion.

Having previously reported orally to the Council the results of the Conference of Delegates, and as much uncertainty and ignorance exist (even among the delegates themselves) as to the functions of the delegates, I have been requested to draw up a short report of what was done at Aberdeen, and to state the object of the appointment of Corresponding Societies of the British Association. To do this, it will be necessary to give a short sketch of the history of the movement which resulted in the formation of a special committee of the British Association, called the Corresponding Societies' Committee.

There is, as you are well aware, a multitude of scientific associations or societies, scattered over the length and breadth of

research which may be thought practicable and valuable to science. It seems to me that our Society could help, as it has already done through some of its members, by carefully recording the rate of increase in underground temperature, and the nature of the strata in all new borings and sinkings in our local coal-fields.

The quality and quantity of underground water met with in coal-mining. Its salinity and probable source.

Regular and simultaneous observations of the barometrical changes on the surface and in the mine might lead to valuable knowledge.

Then there are those earth movements, gentle tremors and pulsations, of which we are not personally conscious, but which are perceptible only by the aid of delicate seismographs or earthquake recorders. These micro-earthquakes are probably continuous and universal, but their cause is still to seek, whether due to barometrical variations, magnetic disturbances, or other source. It would be interesting to know whether these tremors exist below the surface or whether they increase in intensity with the depth.

Again, I would suggest, to those of our members who take an interest in the coal measure flora and fauna, the careful tabulation of the fossils met with in the various beds, a correct knowledge of which is not only useful to the miner, but may greatly assist the palæontologist in working out the life history of that important epoch in the world's history,—the Carboniferous age.

DISCUSSION ON "THE EFFECTS OF ATMOSPHERIC CHANGES UPON THE DEVELOPMENT OF FIRE-DAMP IN MINES, AS DEMONSTRATED BY EXPERIMENTS AT KARWIN, IN AUSTRO-SILESIA."

(*See Translation of Report—Transactions, Part* xiii. *page* 351.)

Mr. MARTIN said: I have received a copy of a paper, which is printed in German, read by Mr. Edward Suess, in which reference is made to this subject. He gives credit for the exertions made with the view of reducing the number of accidents to workmen generally, and points out that in this country where many explosions have taken place

great exertions have been made to reduce them as much as possible, but, he says, it will require not only to theorise on the means, but also to have them practically demonstrated by experiments. He points out that, in two instances, experiments have been set on foot to put to the test the supposed cause of explosions,—one by the Prussian Government, at "Konig grube" bei Neun-Kirchen, in the Saar coalfield,—the place where the experiments with coal dust took place—and the second at the Archduke Albrecht's colliery at Karwin, to which the paper about to be discussed relates. He points out also with respect to atmospheric changes having an effect on fire-damp, that at Carlsbrunn, in Silesia, it has been noticed that the wells have been affected by the movements of the barometer. He says that in the years 1859 and 1860, Dr. Cartellieri, in Franzenbad, made a long series of observations and showed that one of the wells, or springs, had entirely ceased to flow, and that they had been observed regularly to stand higher and lower at various periods, according to the movements of the barometer. He also points out that at Stromboli there was another instance where, with a very high rise of the barometer, the flow of the well, or spring, ceased. He thinks that probably from the time, say of Homer, this ceasing of the water to flow had been observed as warnings of the approach of storms. Then he goes on to say that there have been many experiments by English engineers; and he mentions that, as far back as 1852, Mr. Dickinson, the Inspector of Mines for North and East Lancashire, expressed the opinion that atmospheric changes had some effect upon mines; and he refers also to the discussion in the House of Commons on the 27th June, 1878, when Mr. Cowen, the member for Newcastle, mentioned the subject and proposed that the Governmeut should by telegram communicate to all collieries any probable changes in the atmospheric pressure. He calls attention to

Messrs. Scott and Galloway's paper in the proceedings of the Royal Society in 1872, in which they compared the observations taken at Stonyhurst Observatory (which was supposed to occupy a central position as regarded the colliery districts of England) and the number of explosions that occurred. He speaks of the work of Nasse, in Germany, referred to in the paper for discussion. He says, however, that he does not consider the explosions an absolute test with reference to the effect of atmospheric changes upon fire-damp, because not only is it necessary to have an increased quantity of gas, which may occur from other causes; but it is also necessary to have a light to ignite it; hence it can hardly be considered as proof definite on the subject.

Mr. DICKINSON handed to the President a diagram which he said was one he made in the year 1852, and was published in his report of the following year, and laid before a House of Commons Committee sitting on coal mines. It shows (Mr. Dickinson continued) the days on which fatal explosions took place in the district and adjoining districts, during the year 1852, with the variations of the barometer and thermometer, the difference between the wet and dry bulb thermometers, the daily fall of the rain and the state of the weather. This was the first diagram of the kind that I know of; and it was difficult to trace any connection between the barometer and the explosions. Boisterous winds, it was noticed—and it has been generally noticed—affect the ventilation of shallow pits.

The PRESIDENT: Shallow pits much more than deep pits?

Mr. DICKINSON: More than deep pits. The diminution of the density of the air, as tantamount to the diminution caused by a falling barometer, has been considered, and the same with respect to expansion by increased temperature. The subject is one which has been gone into on many occasions, but, as the gentleman whom Mr. Martin has just

quoted truly says, you require first to have the gas, and secondly the light; so that it is very difficult to trace any connection between an explosion and the issue of the fire-damp. Then it has to be considered what an immense number of causes may operate to increase the accumulation of fire-damp—a fall of roof in the air-way, or the leaving open of a door, or a slackening of the ventilating power—any of these may tend to increase gas in the air. But that there is a connection, as stated in the paper we are now discussing cannot, I think, be denied. There is always some gas near the surfaces of the coal which is being worked that will find freer vent when the pressure against it is less than it finds when the pressure is greater. We had it stated at our last meeting that some of these pressures of fire-damp got up to near 500lb. on the square inch, and how far these would be operated on by a change in the barometer it is difficult to say; but I do not, myself, think it would be much, if at all. There is a gentleman here (Mr. Henry Wilde) who has recently made some experiments on this very subject; and he has put them into such a practical form—and they seem to bear so particularly on the issue of gas under high pressure into mines—that I hope he will be induced to give us a short outline of his paper on the subject, which would be most valuable to have in our own Transactions as well as in those of the Literary and Philosophical Society.

Mr. Henry Wilde said: I should have great pleasure in complying with your request, but I feel at present a difficulty in applying my experiments to this particular question. I may at some future time give you a condensed account of my experiments, which may be useful to place on record in your Transactions. In fact, I am continuing my experiments still further, and I shall have a further communication to make to the Literary and Philosophical Society.

The PRESIDENT: As has been stated, there must not only be the gas but also the light, and in many of the rapid rises and falls of the barometer then two things may not always be present. But the result of the Austro-Silesian experiment appears to have been mostly, what is stated, namely, that the danger is not either in the height of the barometer, or in a very low barometer, but in the effect of the rapid change in bringing gas out. I do not know whether that has been found exactly so here.

Mr. MARTIN: I think this is the first time there has been any experiment on the subject, practically. I omitted to say that Mr. Suess, in giving the mining engineers of this country credit for the opinion that the pressure of the atmosphere affected the issue of gas, refers also to the fact that the French and German engineers have hitherto rather objected to the idea, and refer as their reason to the point which Mr. Dickinson has mentioned, namely, that, whilst the gas is held in the coal, at such high pressures as stated, changes of the barometer could not affect it much. Still the results of these experiments, in a mine where the down-cast shaft was closed and the fans were kept at work, are stated to have been as follow:— Where the shaft was effectually closed, with a fall of 2·5 mm., the percentage of gas increased 83 per cent., in the seam where the workings were in the solid coal; but later, where the shaft was effectually closed and a fall of 4 mm. was obtained, it increased to 135 per cent., acccording to the experiments and analysis; so that there can be little doubt that an effect is produced, even on the solid coal. The experiments are being continued, and we shall have a further report later on.

Mr. DICKINSON said: The North of England Institute of Mining and Mechanical Engineers have published a diagram which shows the atmospheric pressure, and also where every

fatal and non-fatal explosion in the kingdom took place, and it is really very difficult to trace any connection between the state of the barometer and the explosions. There are so many causes under which gas accumulates in a mine, yet we have these cautions issued to us once a week or once a fortnight in the newspapers, telling people who are engaged about coal mines to use "extra care," and I am not sure whether these spasmodic warnings do not do a great deal more harm than good. It requires continual care at all times in a pit—the utmost care, at all times—and to tell people that they are to use "extra care for the next two or three days"—as I think is said in the papers this morning—it seems to be implied that people may use less care at other times. Now there ought to be no relaxation. I do not know who is the author of these warnings, but I should infer that he is not a man who is practically conversant with fire-damp in mines.

Mr. MILES SETTLE: From my experience I must say that these warnings upset the colliers' minds. The system on which they are now published is objectionable. I always find, in practice, that the danger has come before I see it in the newspapers. The manager, when he comes out of the pit to breakfast or dinner, if he sees the paper, must naturally conclude that those who supply the report must think that both master and manager are lax in their duty. Frequently it happens that the men are in the pit before anything is known of the published warning. As to the effects of high pressure and low pressure I find a great difference in our fiery mines in Staffordshire. With a quick fall or rise of the barometer there is an extraordinary amount more gas given off than with an ordinary standing barometer.

The PRESIDENT: As well at the rise as the fall?

Mr. SETTLE: Yes.

quoted truly says, you require first to have the gas, and secondly the light; so that it is very difficult to trace any connection between an explosion and the issue of the fire-damp. Then it has to be considered what an immense number of causes may operate to increase the accumulation of fire-damp—a fall of roof in the air-way, or the leaving open of a door, or a slackening of the ventilating power—any of these may tend to increase gas in the air. But that there is a connection, as stated in the paper we are now discussing cannot, I think, be denied. There is always some gas near the surfaces of the coal which is being worked that will find freer vent when the pressure against it is less than it finds when the pressure is greater. We had it stated at our last meeting that some of these pressures of fire-damp got up to near 500lb. on the square inch, and how far these would be operated on by a change in the barometer it is difficult to say; but I do not, myself, think it would be much, if at all. There is a gentleman here (Mr. Henry Wilde) who has recently made some experiments on this very subject; and he has put them into such a practical form—and they seem to bear so particularly on the issue of gas under high pressure into mines—that I hope he will be induced to give us a short outline of his paper on the subject, which would be most valuable to have in our own Transactions as well as in those of the Literary and Philosophical Society.

Mr. Henry Wilde said: I should have great pleasure in complying with your request, but I feel at present a difficulty in applying my experiments to this particular question. I may at some future time give you a condensed account of my experiments, which may be useful to place on record in your Transactions. In fact, I am continuing my experiments still further, and I shall have a further communication to make to the Literary and Philosophical Society.

The PRESIDENT: As has been stated, there must not only be the gas but also the light, and in many of the rapid rises and falls of the barometer then two things may not always be present. But the result of the Austro-Silesian experiment appears to have been mostly, what is stated, namely, that the danger is not either in the height of the barometer, or in a very low barometer, but in the effect of the rapid change in bringing gas out. I do not know whether that has been found exactly so here.

Mr. MARTIN: I think this is the first time there has been any experiment on the subject, practically. I omitted to say that Mr. Suess, in giving the mining engineers of this country credit for the opinion that the pressure of the atmosphere affected the issue of gas, refers also to the fact that the French and German engineers have hitherto rather objected to the idea, and refer as their reason to the point which Mr. Dickinson has mentioned, namely, that, whilst the gas is held in the coal, at such high pressures as stated, changes of the barometer could not affect it much. Still the results of these experiments, in a mine where the down-cast shaft was closed and the fans were kept at work, are stated to have been as follow:— Where the shaft was effectually closed, with a fall of 2·5 mm., the percentage of gas increased 83 per cent., in the seam where the workings were in the solid coal; but later, where the shaft was effectually closed and a fall of 4 mm. was obtained, it increased to 135 per cent., according to the experiments and analysis; so that there can be little doubt that an effect is produced, even on the solid coal. The experiments are being continued, and we shall have a further report later on.

Mr. DICKINSON said: The North of England Institute of Mining and Mechanical Engineers have published a diagram which shows the atmospheric pressure, and also where every

fatal and non-fatal explosion in the kingdom took place, and it is really very difficult to trace any connection between the state of the barometer and the explosions. There are so many causes under which gas accumulates in a mine, yet we have these cautions issued to us once a week or once a fortnight in the newspapers, telling people who are engaged about coal mines to use "extra care," and I am not sure whether these spasmodic warnings do not do a great deal more harm than good. It requires continual care at all times in a pit—the utmost care, at all times—and to tell people that they are to use "extra care for the next two or three days"—as I think is said in the papers this morning—it seems to be implied that people may use less care at other times. Now there ought to be no relaxation. I do not know who is the author of these warnings, but I should infer that he is not a man who is practically conversant with fire-damp in mines.

Mr. Miles Settle: From my experience I must say that these warnings upset the colliers' minds. The system on which they are now published is objectionable. I always find, in practice, that the danger has come before I see it in the newspapers. The manager, when he comes out of the pit to breakfast or dinner, if he sees the paper, must naturally conclude that those who supply the report must think that both master and manager are lax in their duty. Frequently it happens that the men are in the pit before anything is known of the published warning. As to the effects of high pressure and low pressure I find a great difference in our fiery mines in Staffordshire. With a quick fall or rise of the barometer there is an extraordinary amount more gas given off than with an ordinary standing barometer.

The President: As well at the rise as the fall?

Mr. Settle: Yes.

fatal and non-fatal explosion in the kingdom took place, and it is really very difficult to trace any connection between the state of the barometer and the explosions. There are so many causes under which gas accumulates in a mine, yet we have these cautions issued to us once a week or once a fortnight in the newspapers, telling people who are engaged about coal mines to use "extra care," and I am not sure whether these spasmodic warnings do not do a great deal more harm than good. It requires continual care at all times in a pit—the utmost care, at all times—and to tell people that they are to use "extra care for the next two or three days"—as I think is said in the papers this morning—it seems to be implied that people may use less care at other times. Now there ought to be no relaxation. I do not know who is the author of these warnings, but I should infer that he is not a man who is practically conversant with fire-damp in mines.

Mr. Miles Settle: From my experience I must say that these warnings upset the colliers' minds. The system on which they are now published is objectionable. I always find, in practice, that the danger has come before I see it in the newspapers. The manager, when he comes out of the pit to breakfast or dinner, if he sees the paper, must naturally conclude that those who supply the report must think that both master and manager are lax in their duty. Frequently it happens that the men are in the pit before anything is known of the published warning. As to the effects of high pressure and low pressure I find a great difference in our fiery mines in Staffordshire. With a quick fall or rise of the barometer there is an extraordinary amount more gas given off than with an ordinary standing barometer.

The President: As well at the rise as the fall?

Mr. Settle: Yes.

The PRESIDENT: I often read these warnings, and I quite agree in thinking that if the notice says they must use "extra care," the men may infer from that that if there does not happen to be a rapid fall or rise they may be a little easy.

Mr. S. GARSIDE: I believe these notices do more harm than good. I have had the same difficulty with my people that the previous speakers have referred to; they think they may use more care at one time than at another. Of course everyone connected with a colliery ought to be using the utmost care at all times; and the publication of these notices is, in my opinion, a sad mistake.

DESCRIPTION OF A NEW SAFETY LAMP.

By WILLIAM CLIFFORD, M.E.

The lamp before you has the ordinary oil vessel with wire pricker. The cylindrical glass is somewhat longer than usual in safety lamps. The wick tube is so placed as to bring the flame into the centre of the glass. Inside the glass is a bell-shaped chimney, also of glass, pinched in at its upper part, and fastened to a brass nut which screws on to metal flue. This allows of the chimney hanging free, instead of resting on a gallery, as in larger, or station lamps. The gauzes are horizontal, and are of wove wire, or of perforated metal. Those at inlet are annular in form, those at outlet are simply discs.

In larger lamps for pit bottoms, incline planes, and stations, where each particular lamp is not for the personal use of some individual, a fusible faced gauze is used.

The outlet gauze is placed in an arbour in the upper diaphragm, and held in position by the cover bearing against a shoulder round the inside of inner skin.

At outlet and inlet are annular chambers communicating with inside and outside of lamp by means of ports at, or nearly at, a tangent to walls of chambers. Between the chambers there is direct inter-communication through space between solid skins of metal. The inner skin being filled with the diaphragms, prevents any communication between inlet and outlet inside the lamp.

A wind entering the tangential holes or ports, which are in rows one above another, as will be seen, sets up suction at inlet and outlet equal in force, and therefore only so much air, or air and gas, enters the lamp as may be drawn in by rarification. It is believed that when the ports at inlet and outlet are made identical in construction and dimensions, by the machinery shortly to be brought into use, the lamp will be self-extinguishing *at any velocity.*

The fusible gauze is placed in such a position that its face will not fuse under ordinary conditions of burning. It requires 8 minutes exposure to a blow-pipe test at 12 W.G. pressure to fuse it, and put out the lamp in that way. Clanny, Muesler, and Marsaut lamps may, by the application of this invention, be made equally safe with the one before you at one-half the cost; that is, the oil vessel and cradle can be utilised.

The writer is anxious to have his lamp thoroughly tested, and is willing to submit it to any test, competitive or otherwise, on two conditions—first, that the test shall be public; and second, that it shall be pursued to the ultimate resisting power of all lamps tried; that is, till lamps explode externally. Mr. C. Rhodes, a gentleman well known as an expert in safety lamp matters, has, I believe, tested my lamp, and brought, or is bringing, it before the notice of the Midland Institute of Mining Engineers.

THE PROGRESS OF ELECTRIC LIGHTING IN MINES.

By Mr. Thomas Connolly, E.E.

I notice, by the circular, that I am to read a paper on "The Progress of Electric Lighting in Mines." A paper, however, I have not prepared, because, in the first place, I considered that a subject wide as this could not be dealt with, in all its details satisfactorily, in a paper. Electric lighting has, during the last five or six years, progressed with leaps and bounds; therefore, instead of reading a paper, I will offer a few remarks on the question of the application of electricity to the working of coal mines, and state to you the practical outcome of the theoretical ideas which have been put forward. This subject as far as I am concerned, is not the work of to-day or of yesterday. I was born in a mining district, and reared in the midst of miners, and I can recollect hearing in my earliest days something of the awful effects of explosions. Since my connection began with the electrical world I have never ceased to study how electric lighting could be applied so as to meet the daily wants of the miners. I have heard from friends who have spent all their lives about mines, workmen, viewers and mining engineers—of the vast amount of coal that lies practically unworked because the seams are so fiery. They are especially so in the Killingworth district and about Hartley, where there is any amount of good coal which could be worked if it were possible to reach it with safety. Thinking over this matter I have wondered many times if it were not possible to utilise this last new illuminant in such a way as to enable the coal to be got at without risk either to the life of the working miner or the money of the capitalist. I need not tell you—those of you who have to work in connection with mines in Lancashire, which are more or less fiery—of the

necessity that exists for such a thing as this. Attempts have been made especially during the last four years, to carry out the ordinary incandescent system of lighting, in various districts; and I believe it has been carried out with more or less success—in some particular districts with very great success—so, in order to get at the results, I have written to a number of gentlemen who have been engaged in the practical work of mine lighting for information. One of the first to carry electric lighting of mines to a successful issue was Mr. Sidney Walker, of Cardiff. He persuaded certain mine owners to allow him to try the system in their pits. Try it he did, and after three years it is still at work. That, of course, does not say that the thing will be a success for ever: still three years is a very fair test of what may be done. I wrote to Mr. Walker for definite information, and he replied as follows:—

Severn Road, Cardiff.

THOMAS CONNOLLY, Esq., Alexandra Works, Varley Street, Oldham Road, Manchester.

Dear Sir,

In reply to your favour of yesterday, I have much pleasure in giving you the following information.

We have one colliery in this district where incandescent lamps have been in use underground for three years past. There are 40 lights of 20 c.p., 48 volt lamps, and they are worked by a Gramme machine at the bottom, driven by a Soho engine, using compressed air. The lights are used for the pit bottom (two), for the engine houses, and main roads in all directions. The farthest lamp is, I believe, about 500 yards from the dynamo, and there are several thousand yards of supply mains of different sizes. The pit being a deep one, and there being compressed air at the bottom, it worked out cheaper to put a separate engine and dynamo underground than to take cables down the shaft, although we had a large dynamo on the surface with surplus power.

The only difficulty we have had with this installation has been

from falls of roof, which is very bad in this district, often altering the roads and doing much damage; but in spite of that it is considered a great boon, and has been entirely under the charge of the colliery officials since it was first put in, we paying them an occasional visit.

We have also now three other installations in the North of England—one that has been running two years, a second eight months, and a third about two months.

In each case the dynamo and engine are underground, in one seam, and cables are led into the others. We light three and four seams. The engines are driven by steam, which they have underground in the North, and the lights are used for the pit bottoms, engine houses, main roads, stables, &c.

There will be several thousand yards of main cables in each pit.

With these we have not had the smallest hitch since put up, and they have been entirely in the hands of the colliery officials.

Yours very truly,

SYDNEY T. WALKER.

In another case, in the North of England, they have had the installation running for two years, in a third it has been running for eight months, and in a fourth for four months. In one of these cases they increased the installation by a considerable number of lamps, showing that the colliery proprietors approved of the system and found it to work well. That, I consider, is a step in the right direction. I know, also that the system has been tried in Scotland, but principally for bank, or surface, illumination; it has also been taken down the pits, and into the main roads. The system having been thus tried, the question arises—can we carry it further? After the unfortunate explosion at Pendlebury there seemed to be no end of the craze, amongst certain people, in favour of compulsory lighting by electricity; and Lord Thurlow—backed, I think, by the name of Mr. Andrew Wade—stated in the *Times* that "the problem was already solved." They said that the electric light

was as easy to manage in a coal mine as on the surface, and a law should be passed compelling all mine owners to use the electric light. For a time it created a great scare. Now, to me individually, it would be a great advantage to enact such a law; but, putting aside that, I think, in the present state of electric lighting, it would be a great mistake to try and enforce anything of the kind. I say this because, although so much has been done already, I believe there is a great deal yet to be accomplished. The more I study the matter the more I am convinced of this. I must explain how the practical application of electric lighting in mines is aimed at. Mr. Sidney Walker states that it is thought better, in Wales, to place an engine and dynamo at the bottom of the pit, instead of carrying the wires from the surface. That is a matter of detail; I, individually, would advocate rather that we should have it from the surface, where the machinery is best seen, and where it can be better attended to in the daytime than would be possible below. And, after all, what does the question amount to? I have here a rough sectional map of a coal field, with two or three—it may be four—shafts; I will take it, however, that there are only the ordinary up-cast and down-cast shafts. I would place the dynamo on the surface and carry down the main leads to the pit bottom. There might be two of them, reaching to the bottom seam. It would, of course, be just as easy to carry the current from the top as to generate it below, always making allowance that the main cables are of sufficient capacity to convey the current, so that the difference between running the machine from the top and from the bottom would be simply the difference in cost of the lengths of wire from the surface to the seams below. With proper care, the same machinery being applied to bank lighting at the same period, I think the extra cost of cable would be more than recompensed by the

advantage of having it placed there. Our system, say, in a colliery needing a very large number of lights, would be thus: there would be a main cable leading from the dynamo machine, consisting of 37 or other suitable number of wires twisted together so as, really, to form only one wire. They are twisted and made into a cable for the sake of flexibility. That cable would be carried down the main shaft. There would also be a return cable, of similar construction. From the pit bottom the current would be carried to the far end into the whole of the workings in exactly the same manner as gas pipes are carried in a house, over a large area. In fact the business, now, has been brought to this: We have the larger main, the secondary derivation for the smaller area; the smaller derivation again for the smaller number of lamps, as you get nearer the headings; and the ultimate wire carried to the heading itself. I say, then, that in cases of this kind it is possible to carry the wire not only into the main roads but also right up to the coal face, where there is a moderate degree of safety. Now you will note why I say this. I say it because in fiery seams a careless or stupid miner might do damage to a certain part of the system that might—I do not say that it would, but it might—cause an explosion. It is still a question in this case, whether an electric spark would do what the flame of a lamp would do. It is said by some that there must be a flame to ignite gas, but if the electric spark will decompose gases it will also explode gases. The question of whether the spark is sufficient in intensity, or quantity, under the conditions that would be present in a mine is a matter for further consideration. One thing I do know—that there have been, and there are now, mines existing where the wire is carried right up to the coal face, and it is found to be of use there. The Adlington Colliery is lit at the bank and sidings, and in one case the light is carried down to the

bottom and into one of the main roads. Then we have a number of collieries also lit in the same fashion, but in these cases the wires are only carried as far as the main roads. The Low Moor Coal and Iron Company have carried the electric light into the Lofthouse pit, taking the derivations right up to the coal face. The miners have a protected lamp, which is capable of being moved from place to place. The Lofthouse mine, I presume is a fairly safe one. Well, including the case the question comes—Can we bring the electric light into practical use? Now, in carrying out this notion, I would like to combine, as far as I am concerned, the two systems—that is, the system of the conveyance of the electric current through all the main roads—everywhere as far as you can go up to the lamp station. In a large colliery, where it is so arranged, I think with every chance of safety, it could be carried up to that point, at all events, and even beyond; but, assuming that it may be carried so far, let us see how it may be done in a practical manner. The difficulty has been suggested of providing against accidents by falls. I will suggest a means by which this may be overcome. (Mr. Connolly here exhibited a sample of the cable which should be carried down the pit, and along the main roads, for certain distances. It consisted of a number of wires, twisted together to form one main conductor, and protected with coverings of cotton, india-rubber, and other substances). We have, (he continued) a cable at the present time with an insulation which ten years ago could not have been got for four times the cost. It is the result of long study, the object being to get the cheapest and best cable which would enable us to embark on enterprises like these and yet have a return for the capital expended. In cases of falls of roof, say of several tons weight, or of a crush, it may be said that this cable would be entirely squeezed up. I venture to think that

it would take a good deal more force than is ordinarily met with, unless it came in contact with jagged points, to crush through this insulation and render it incapable of retaining the current. But I place in between the lengths a flexible cable I have myself made, so that in case of seams rising or falling, the electricity could be carried with the same facility as gas for illuminating purposes. At various places we have this electric cable, and were a crush to take place it would carry this cable backward or forward, as the case might be, without breaking continuity; consequently, although there is a fall of roof, behind that fall the men will still have light—the light not requiring the support of atmospheric air—and by its aid the men could see and try to work away back. I would also carry with the cable which conveys the light a smaller wire, called a life-line, acted upon by a switch, by means of which every man of ordinary intelligence could be taught how to indicate whether those imprisoned behind a fall were still living, whether they were suffering from want of air, and in many ways be able to assist those out-bye in their attempts at rescue. These are things which I suggest as open to practical observation. Now, supposing this system to be carried as far as the lamp station: would it be safe to carry it in-bye or no? In many cases I do not believe it would. Then we come back to the problem which is being fought out—the safety lamp of the miner. Wishing to get at the very best head in regard to progress in this particular line, I wrote to Mr. Joseph W. Swan. I had seen the report of his paper in the Transactions of the Northern Institute of Mining Engineers, and I had also heard of the very great amount of attention that had been called to it at the time; and it was thought that it almost solved the problem. I asked Mr. Swan if he would be good enough to lend me his lamp, or, if that was not possible, to give me

what particulars he could in regard to the lamp. Mr. Swan wrote me, in reply to my letter, as follows :—

Lauriston, Bromley,
Kent.

Dear Sir,

I have the pleasure to send you herewith a copy of the paper I read in Aberdeen on my miners' electric lamp.

I am afraid I cannot promise to send a lamp for the meeting you refer to, for I am making improvements in it just now, and wish when it is shown in your locality to show it with these improvements.

Perhaps there may be another opportunity later on.

J. Wilson Swan.

That seems to indicate that he is going on with this important business, and that some day we may have a chance of seeing the lamp down here, and have the opportunity of passing judgment upon it.

During the last three or four years we have heard about once or twice every month about some new lamp having been discovered. One of the latest was reported in the *Manchester Examiner and Times* about five weeks ago: it was stated that a new lamp had been discovered, and was being made by a London firm, which would burn for twelve hours and give a light of two-candle power. This lamp, it was said, was equally safe turned over on its back or placed in any other position, and the miner could not destroy it. It was, moreover, cheap in construction. The battery was said to be made by chloride of mercury. Well, I thought, if that is so, this is an old friend, so I went to the Portable Battery Company, who make the portable electric appliances for lighting gas lamps in manufactories, &c., to inquire about it. A chloride of silver battery is the base of those

little appliances. They had, they said, heard of the German lamp (that described in the newspapers), and thought they would be able to get one. The week following, in the *Electrician*, I read that this lamp had been introduced at a miners' conference by Mr. Thomas Burt., M.P., who spoke highly of it, and said it was a great success. Thereupon I wrote to Mr. Burt for information, and he replied stating that he wished it were true; he had never seen the lamp, and therefore could not have spoken in its favour. He added that the only lamp, up to date, of which anything could be said in its favour, was that of Joseph W. Swan, who had great hopes that he would ultimately produce a lamp which would be of great use. Mr. Burt further said that the report of the Mining Commission would be out in three or four weeks, and he hoped we should be able to get some valuable information from that.

Mr. CONNOLLY then exhibited a small portable battery (kindly lent by the Manchester Edison Company), and explained its construction. Although, he said, it was too large for use as a miner's lamp, it contained only about two hours of light. But Mr. Joseph Swan had been enabled to get twelve hours of light beginning with about 1½-candles power, from the lamp which he exhibited at the meeting of the Institute of Mining Engineers, and of which a description was given in the Transactions of that Society. The battery with lamp and all complete weighed 6¾lbs., which was a very great obstacle in the way of its practical use. Miners would object to carry such a weight about with them. Mr. Swan showed that when the switch had to be used for the purpose of making or breaking contact—that is, to make the current complete, or to break it—a spark is emitted. To obviate this he covered the point of contact with a drop of oil—a beautiful contrivance which would prevent any

danger, whether danger existed or not—although the spark was so minute that a high magnifying power was needed in order to see it. Mr. Swan, moreover, pointed out that with 12 hours' lighting capacity there would be very little occasion for any use of the switch at all. The only use in it was to enable a man to turn the light on or off at any time required. The light from the battery now exhibited—an Edison storage battery—could just as easily be turned on or off as the gas in a house. The members would judge how much superior a light it gave to anything now within the power of a miner to obtain. This was the ordinary Swan lamp. What he would suggest, in the event of their deciding to employ the electric light, was the Swan-Edison lamp to hang in the main roads protected against injury from splinters or anything else knocking against it. But in places where there might be danger from blasts—places in-bye—the lamp should be provided with a strong glass cylinder. It was possible he thought, to make a glass tube that could resist even the blow of a hammer. He would, then, cover the lamp with one of these strong tubes and abandon the gauze covering altogether. The lamp could then safely be exposed. These lights were in use at Messrs. Platt's, at Oldham, in their mill-wrights' shop, and it had been found for a considerable time that the gauze covering was sufficient protection. Now, to prevent danger from the spark, Mr. Swan enclosed the bulb in a kind of bull's eye, so that the spark would not be in contact with any gas, no matter with what force it might be delivered.* The light was in a vacuum, enclosed within the bull's eye or glass tube, and until that vacuum was pierced it remained intact. In conclusion, Mr. Connolly said he had occupied a good deal of the time of the meeting, but if what he had said had

* Say from a "blast" or "blower."

been of any use towards solving the problem of the electric lighting of mines their time would not have been wasted, because it was one of the most desirable things to enable the holders of valuable properties, and those who worked them, the one to realise the fruits of his capital and the other the fruits of his labour without any danger to life or limb. Some experiments conducted on the previous Saturday, before some of the first electricians in the country, at the works of Messrs. Mather and Platt, in Salford, illustrated the latest development of electric power. It was proved beyond doubt that with a seven-horse engine at work upon two Edison-Hopkinson dynamos, coupled up in a peculiar way, 100 horse-power was developed between motor and generator.* No such power could be got from coal. In the steam engine, if we have one-tenth of the power given out in heat from the coal we think we are well off; in the experiments referred to they got 92 per cent. Dr. Edward Hopkinson himself vouched for the statement that, by an installation of this kind, lamps could be kept burning a mile from the pit bank, each one as brilliantly as that next to the dynamo itself; and if they shut off 20 or even 100 lights in a branch of the pit it will not affect the remaining lamps in the least.

Mr. Dickinson moved a vote of thanks to Mr. Connolly for his valuable communication, and also to Mr. Clifford for exhibiting and explaining his lamp to the meeting.

The resolution was seconded and unanimously passed.

Mr. Stirrup suggested that, owing to the lateness of the hour, the discussion upon the paper might be taken at a subsequent meeting.

---

* The seven horse-power representing the loss in friction.

Mr. CONNOLLY said he should be glad to attend the meeting at which the discussion might be taken, and answer any question.

The discussion was thereupon postponed.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XVIII. SESSION 1885-6.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, April 6th, 1886, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

The President, H. M. ORMEROD, Esq., F.G.S., in the Chair.

The following are the recent additions to the Library :—

Chesterfield and Midland Counties Institution of Engineers: Transactions, Parts 4–5, Vol. XIV.—*From the Institution.*

Cornwall, Royal Geological Society of: Transactions, Part 8, Vol. X.—*From the Society.*

Ditto, Royal Institution of: Journal, Part 4, Vol. VIII.—*From the Institution.*

Dublin—Royal Geological Society of Ireland: Journal, Part 3, Vol. VI., New Series, 1882–84.—*From the Society.*

Dundee—Report of Free Library Committee, November, 1885.

Hertfordshire Natural History Society and Field Club: Transactions, Part 7, Vol. III.—*From the Society.*

Leeds Geological Association: Transactions, Part 1, 1883–5.—*From the Association.*

Liverpool—Thirty-third Annual Report of Free Public Library, Museum, and Walker Art Gallery, 1886.

London—Geological Magazine, January to March, 1886.—*Purchased.*

Ditto, Institution of Mechanical Engineers: Proceedings, No. 5, October, 1885.—*From the Institution.*

London—Royal Society: Proceedings, Nos. 240-241, Vol. XXXIX.—*From the Society.*

Ditto, Geological Society: Journal, No. 165, Vol. XLII.—*From the Society.*

Ditto, Geologists' Association: Proceedings, No. 4, Vol. IX.—*From the Association.*

Ditto, Royal Institution of Great Britain: Proceedings, No. 79, Vol. XI., Part 2.—*From the Institution.*

Ditto, Iron and Steel Institute: Journal, Vol. II., 1885.—*From the Institute.*

Ditto, Palæontographical Society: Vol. XXXIX.—*Purchased.*

Manchester Association of Engineers: Thirtieth Annual Report, 1885.—*From the Association.*

Ditto, Pamphlet: Use of Steam for Canal Boat Propulsion, by W. H. Bailey.—*From the Association.*

Ditto, Pamphlet: The Progress of Printing, by Thomas Ashbury, C.E. *From the Association.*

Ditto, Association of Employers, Foremen, and Draughtsmen: Pamphlet, Technical Instruction, by W. Mather.—*From the Association.*

Ditto, Literary and Philosophical Society: Memoirs, Vol. VIII., Third Series.—*From the Society.*

Ditto, Ditto: Proceedings, Vols. XXIII.-XXIV.—*From the Society.*

Midland Institute of Engineers: Transactions, Parts 79-80, Vol. X.—*From the Institute.*

Mining Institute of Scotland: Transactions, Parts 7-8, Vol. VII.—*From the Institute.*

Ditto, Report of Mining Exhibition, Glasgow, 1885.—*From the Institute.*

North of England Institute of Mining and Mechanical Engineers: Transactions, Part 1, Vol. XXXV.

Salford: Thirty-seventh Annual Report of Museums, Libraries, and Parks Committee, 1884-85.

Wigan: Eighth Annual Report of the Free Public Library, 1886.

Yorkshire Geological and Polytechnic Society: Proceedings, Part 1, Vol. IX., New Series.—*From the Society.*

Pamphlet, Memoir of Geological Survey—Geology of Coasts adjoining Rhyl, Abergele, and Colwyn, by Aubrey Strahan, M.A.—*From the Author.*

Ditto, On Fossiliferous Hæmatite Nodules in Permian Breccias, Leicestershire, by W. S. Gresley, F.G.S.—*From the Author.*

Toronto: Proceedings of the Canadian Institute, No. 3, Third Series, Vol. III.—*From the Institute.*

U.S.A., Philadelphia: Journal of Franklin Institute, Nos. 721-723, Vol. CXXI.—*From the Institute.*

Washington: United States Geological Survey, Bulletin Nos. 7-14.—*From Director of the Survey.*

Ditto, Mineral Resources of United States, 1883-4, by A. Williams, jun. *From Director of the Survey.*

Ditto, Annual Report of the Comptroller of the Currency, December 1, 1885.—*From Comptroller.*

Australia: Gold Fields of Victoria, Report of Mining Registrars, September, 1885.—*From the Government.*

Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft, Heft 3, Band XXXVII.—*From the Society.*

Brussels: Société Malacologique de Belgique, Annales, Vols. I.-IX., Vols. XV. and XIX. Procès-Verbaux, January to July, 1885, Vol. XIV.—*From the Society.*

Halle, A.S.: Mittheilungen des Vereins für Erdkunde, 1885.—*From the Society.*

Lausanne: Société Vaudoise des Sciences Naturelles, Bulletin, No. 93, Vol. XXI.—*From the Society.*

Liége: Notes sur les Levés Géologiques, Pamphlet by E. Van den Broeck. *From the Author.*

Paris: Revue de la Legislation des Mines, October-December, 1885, January-February, 1886.—*Purchased.*

Pisa: Atti della Società Toscana di Scienze Naturali. Processi Verbali, 15th November, 1885, 10th January, 1886.—*From the Society.*

Roma: Atti della Reale Accademia dei Lincei, Rendiconti, Fasc. 27-28, Vol. I.; Fasc. 1-6, Vol. II.—*From the Academy.*

St. Petersburg: Memoires de l'Académie Impériale des Sciences, Nos. 3-4, Vol. XXXIII.—*From the Academy.*

Ditto, Geological Committee, Institute of Mines: Journal of Proceedings, Nos. 8-10, 1885.—*From Minister of Domains.*

Wien: Annalen des K. K. Naturhistorischen Hof Museums, No. 1, Band I.

The PRESIDENT exhibited a fossil from the coal measures, which he said he had not been able to identify, and asked Professor Williamson's opinion upon it.

Professor WILLIAMSON said it was without doubt a Lepidodendron, and was in a more perfect state than Lepidodendrons were usually found in, from the fact that its leaf-cushions had been protected from pressure. The specimen had been taken from a nodule.

Professor Williamson then laid upon the table what he thought might interest the members, namely, a series of the plates which had been prepared for the illustration of his work, shortly to be published, on the structure of *Stigmaria ficoides*. The plates had been prepared for the Palæontographical Society; there were fourteen of them, and he thought there was scarcely a detail in the structure of Stigmaria which would not be found in those plates. It was as nearly complete as it well could be. In France and Germany there were very few palæontologists who believed in the English ideas about Stigmaria; still they were very anxious to be convinced. They did not say that English geologists were wrong, but they said: "We cannot accept Mr. Binney's evidence." The late Mr. Binney made many mistakes, and unfortunately those mistakes, being familiar to the Germans, had led them to distrust him on a point upon which he (Mr. Binney) was one of the strongest men he ever knew. When Mr. Binney said that he saw a certain fact in a coal mine he (Professor Williamson) felt perfectly sure that the statement ought to be relied upon; but he had not succeeded in convincing some of his friends on the continent that though Mr. Binney, not being a botanist, fell into many botanical errors, he rarely made mistakes as an observer in the field. What is wanted now is indisputable evidence (such as practical colliery workers might be able to furnish him with) to include in his Stigmarian paper. His friend, the Count de Solms, was preparing a work on Fossil Botany, not for geologists but for botanists. Botanists said: "You write such lots of papers, and they are so bewildering—one contradicting another—that we can make neither head nor tail of them;" and Graf von Solms is anxious that additional information should be furnished on this point. As is well known to us, cases of stems, and "pot holes" connected with Stigmarian roots that had branched,

were not unfrequent in our coal strata. The Germans said: "We have no evidence that anything whatever of that kind occurred," and he had been challenged to find a single instance where the plant had gone through the coal and rooted in the clay below. He said to his friend: "If you will give me time I will find you fifty," because he knew that such instances abounded. Mr. Wild had already given him two very valuable ones, which he should include in his book; and he wanted other gentlemen, if they had recently met with any good examples of the kind, in their colliery work, to be good enough to let him have diagrams of them. Or, if they found examples of Stigmarian roots going through the coal, into the fire-clay below, he should be glad if they would communicate with him. The Germans said: "If you know these things of your own personal knowledge we will believe you." They would not, and he could not get them, by anything that he could say, to believe Mr. Binney and others who have testified to the occurrence of such specimens. If any gentlemen could furnish him with clear, definite facts of that kind he should be very much obliged to them. He suspected there were very few collieries where such evidence was not to be had.

DISCUSSION ON MR. GEORGE WILD'S "SECTION OF MIDDLE COAL MEASURES AT BARDSLEY COLLIERY AND AN INTERESTING DISCOVERY OF CALAMITES."

(*See Part XVI., page 446.*)

The discussion was opened on Mr. Wild's paper, read at a former meeting, by

Mr. M. STIRRUP, who said: The paper was altogether one of that practical kind that was very valuable. It dealt with facts rather than with opinions—facts obtained in the practical working of a colliery in our own neighbourhood; and so far as I remember the detailed section—I

believe it gives instances of the very sort that Professor Williamson is asking for, where *Stigmarian* rootlets go through two or three different beds for a distance of 6ft. to 9ft.

Mr. WILD: In the seat.

Professor WILLIAMSON: I have incorporated a number of facts from that paper in my memoir. They are very valuable indeed; but they do not give the particular examples that I now want. Mr. Wild has given some to me since he read that paper.

Mr. STIRRUP continued: Mr. Wild will no doubt say something on this point, but I hope the example he has set will induce others who are engaged in the practical working of coal mines to give us matter of the same kind. The members of the Society, I am sure, will gladly welcome the presence of Professor Williamson, who, at a recent meeting, was elected an honorary member; and I trust he will favour us with his views upon that portion of Mr. Wild's paper with which he is so competent to deal. With regard to that paper there are one or two points upon which I would like a little further information: first, as to the spherical nodules —any one who could tell us something as to the possible way in which those nodules were formed would, I think, supply information which is at present lacking. It is not unusual to find such nodules in the coal measures; but I would like to ask Mr. Wild if anything of the nature of the larger ones (called, I think, bullions), is found in the same strata?

Mr. WILD: No; I do not think the origin of those is the same as that of the nodules I exhibited.

Mr. STIRRUP: In the South Wales coal field, I believe large nodules of ironstone are found which contain a nucleus of some fossil or other, either plant or animal; and they generally occur in the shales composing the roof of the coal,

not in the coal itself. Their disposition in layers parallel with the strata appears to be the same in both cases. Mr. Wild mentioned the fact of fish remains occurring on the *tops* of the coal seams, and said, " he was not aware of any generally accepted hypothesis for their presence in this position." This position is quite usual, and the explanation given of it seems one that we may fairly accept. It is, that the areas occupied by the carboniferous vegetation were sinking areas, and as they slowly sank the swamps or forests were invaded by water, which one would naturally suppose would bring the fish with it. This submerged vegetation which now forms the coal, would be afterwards covered up by detritus washed down from the land into lakes or lagoons, and therefore it is among this detritus now forming the roof shales of our coal seams that we should naturally expect to find fish remains. But the great interest of this paper is Mr. Wild's discovery of Calamites showing the mode of branching of the stems or rhizomes, a feature which has led to very divergent views. The question as to what is a Calamite is one that has caused a great deal of discussion; and I believe there is no settled opinion—no definition that is accepted by everybody—with reference to it. No doubt Professor Williamson has strong convictions on this matter, but some of his continental friends hold opinions on the question of Calamite *versus* Calamodendron which are at variance with his. The Calamodendron was, according to the continental botanists, and also according to Dr. Dawson,* of Montreal, a separate plant differing from the Calamite in several particulars; on the other hand, Professor Williamson says, that the Calamite is simply the internal portion, that its apparently jointed stem is only a cast of the pith of what others call the Calamodendron. I

* Dawson no longer holds these views as strongly as he formerly did. W. C. W.

must say that it is a puzzling thing to understand how these peculiar fossils can be simply internal and not, as Mr. Wild and others say that they are, the rhizomes or underground rootlets from which sprang that peculiar vegetation resembling the Equisetums of our own day. The Professor will be aware that, in many continental works, these Calamites are figured as from nature, showing rootlets, creeping rhizomes with the Calamitian stems growing from them; and I should like to hear Professor Williamson's explanation of the peculiar modes of growth which these specimens of Calamites show, such as that of the giving off branches at the nodes, and the curious thinning off of these branches or shoots towards the point of attachment, characters which seem difficult to understand if we consider the Calamite as being an internal structure only, and not a plant *per se*.

Professor Boyd Dawkins said: I have read Mr. Wild's communication with very great pleasure, and I think the Society is to be congratulated on having Professor Williamson here this afternoon to throw additional light upon the subject. I certainly, so far as my very limited experience goes, consider that Professor Williamson is perfectly right in the view which he published some time ago, that these objects are merely the casts of the interior of the woody cylinder of the Calamite; that the woody cylinder in 99 cases out of 100 has disappeared utterly; and that the bark, which was enormously thick, in, at all events, a large number, has also disappeared in most of the specimens. The small point of attachment is not in my opinion a difficulty. If we examine the branch of a pine tree, we find a minute portion of pith reaching from the central part of the pine trunk right into the branch. This increases in size as the branch grows larger and larger, and gets away from the bark. With regard to the disappearance of the woody zone, I am sure we are perfectly familiar with the fact that

woody tissue is preserved in the most irregular fashion; in some instances we find every atom of wood has been carried away and the pith only left, as in the case of the Sternbergia. Mr. Wild deserves our thanks for the exceeding care and pains he has taken in working out this series of Calamites; and I think between Professor Williamson and Mr. Wild we are likely to add considerably to our knowledge by the study of these specimens.

Mr. BURNETT: If Calamites could be preserved, in the upper part, in the way I understand they have been preserved, and if they had branched rootlets, assuming that those rootlets had pith running from the one to the other, it is not at all inconsistent—I take it—that the lower part should be preserved along with the upper, and that the outer fleshy covering should be removed, while the continuous chain of pith, connecting the one with the other, should remain. If the plant and its roots did grow in that way and decay took place, followed by fossilisation, the rootlets would be preserved along with the branching parts.

Mr. WILD, in replying to various questions, said: With respect to the spherical nodules, I do not find that there is anything organic about them. In the bed of rock in which they are found there are traces of vegetable impressions; but there is nothing of that character inside the nodules. They differ scarcely at all from the rock surrounding them; they contain a little more lime, a trace of iron, and the spherical portion of the nodule is on the under side. They taper above like a child's blunt whip-top, in most cases; but about a dozen out of 100 or more had a sort of spiral, in addition. What was the origin of them I am unable to say—whether it was vegetable, or whether there was some animal burrowing in the sand, and opening out at the top an aperture for air, I cannot tell. I must leave that to more skilled observers than myself. The nodules occurred in a stratum about 6in. or 8in. thick.

Mr. STIRRUP: Of what extent?

Mr. WILD: In the area of the shaft which was being sunk—11ft. 6in. diameter—I found over 100 of these nodules. They were in a solid bed of rock about 6ft. thick, and 12in. or 14in. from the top of that bed. There was none either above or below. As to their possible origin I am puzzled, but I thought if they were characteristic of the particular rock in which they were found they would form somewhat of a landmark in sinking or tunnelling. The joints that are mentioned are the ordinary perpendicular joints in the rock. Wherever a nodule occurs at one of these joints it has been dislocated, in some cases a quarter or half, in others not more than the eighth, of an inch, and the joint is filled in with carbonate of lime, right through the nodule, thus showing that it has been broken since it got into the hardened state. With regard to fish remains being found on the top of the coal, that is a matter I should like to know more about. These remains, consisting of scales, &c., very much broken, occur usually in the parting, sometimes extending a few inches above it. With respect to the Calamites, I have endeavoured to state in a simple practical manner what I found. The stem or rhizome, as a rule, has less prominent internodal groovings than the branch or shoot, and the internodes are longer and more nearly equi-distant, as in the Equiseta. The nodes and flutings in the branches or shoots are continued in most cases to within $\frac{1}{4}$in. to $\frac{1}{16}$in. of the grooved rhizome. The branches strike off from the stem at the immediate point of contact, nearly at right angles, but very soon take an upward or leading direction. In some Calamites the groovings are so fine that 20 flutings exist in the space of $\frac{3}{8}$ths of an inch, and a clear nodal scar for every groove. I find, in some of the parallel shoots, with very blunt terminals, roots given off from immediately above the nodes down to the

very tip or basal node, but have not up to the present met with a long taper shoot with that character. I can scarcely understand how the point of attachment in one specimen, *C. nodosa*, could have been compressed as it is without having originally a resisting medium either in the shape of a vascular cylinder or some organic part of the plant. If only a pith cavity, filled in with a soft substance, one would expect the sides collapsing.

Professor WILLIAMSON said: If I were to give you a sketch of the real story of the Calamite I should have to talk to you at the very least for an hour. There is no real difficulty connected with any solitary point that has been raised; and the fact is that two-thirds, if not three-fourths, of them have been already dealt with in my Memoirs. This very matter about this slender point coming in contact with the pith of the stem is illustrated by some of my figures, and the popular notion about the branches adhering to the stems by a narrow point, shown to be altogether a mistake; but, then, people do not read, or if they do read, they do not remember; and the consequence is that a considerable amount of ignorance exists with regard to these Calamites. I may, in the course of a few minutes, be able to throw some little light upon the matter; for the whole story is really as simple as it can be. Now, my opponents in France and elsewhere have latterly changed their ground; so that the question under discussion is not exactly what it was in past years. In the first place, we have had to deal with the distinction between Calamite and Calamodendron. That question originally had no existence. The early publications of Brongniart contained no such separation of these plants into two groups. In his original works they were all comprehended under the name of Calamites; but some twenty years later, when he published his classic article on Fossil Plants in a large French encyclopædia, he for the first time

announced his conviction that two very different objects had been comprehended under the common name of Calamites. He chiefly arrived at this conclusion after studying some specimens obtained from the uppermost Carboniferous strata of Autun. These belong to a higher range of coal measures than any that we have in England. When he arrived at the conclusion that the Calamites and Calamodendrons were two perfectly distinct things, his reason for doing so was this: he found some examples like those that Mr. Wild has been showing us to-day—fluted stems with grooves and ridges running down in the way Mr. Wild had pointed out, and which lines are redistributed in alternating order in passing from one joint to another. He was ignorant at that time of what is now so well known, that most of these fluted stems are merely inorganic internal casts of a pith cavity. He believed that the thin coating of coal which was constantly found upon these casts represented the only organic tissue which these plants possessed when living. Not only so, but he also believed that this coal represented those tissues in their normal size and aspect. Such specimens he believed to be Equisetaceous. Of plants of this type Brongniart made no pretence of having obtained any specimens of which the internal organisation was preserved; but he had obtained from Autun a specimen (I recollect his showing me one of these specimens forty years ago), in which he found a zone of large woody wedges surrounding the pith cavity; and he was too excellent a botanist not to know that every one of these woody wedges meant exogenous growth. He did not believe, and nobody in those days did believe, that exogenous growth was possible in a Cryptogam, to which section of the vegetable kingdom the Equisetums belong, and therefore he naturally concluded that a plant having exogenous growth must necessarily be something different from a Cryptogamic Equisetum. Such was the origin of the separation of Cala-

mite from Calamodendron. When I came to investigate the subject fourteen years ago I very speedily found that the differences then relied upon by Brongniart were merely such as resulted from differences of age; and I say so still. You may get these Calamites—and I have figured such two or three times over, in a young state, where the woody zone consists of little more than a circle of small canals close to the circumference of the specimen, with scarcely any trace of woody tissue externally to these canals; and I have similar young stems in which the bark invests the circle of these canals but with scarcely any trace of vascular tissue between the two circles—though in reality there is more of this tissue in the youngest specimens than is seen in the same position in a recent Equisetum. Such specimens are minute, probably not more than the 20th or the 30th of an inch in diameter. They are evidently either mere seedlings or the smallest twigs. But the specimens in my cabinet represent the same objects in every stage of their growth, from the minute objects referred to, up to stems that must have been more than a foot in diameter. Thus you see the only distinction between Calamites and Calamodendron, *recognised by Brongniart*, is proved merely to represent different stages of growth. Now there is, I am convinced, no answering what I have said about this matter, so far as these two conditions, which Brongniart recognised, are concerned; and when M. Renault and others of my opponents originally wrote or spoke in favour of the Brongniartian notions *they* recognised no other distinctions than those which, as I have shown, have not even a specific value. My opponents have advanced so far that they now acknowledge that the cast of the central pith-cavity of what they call the Calamite cannot be distinguished from the similar cast of the central pith-cavity of a Calamodendron. They admit that these cases are undistinguishable, an important admission of a

truth respecting which there is no possibility of doubt. But I have recently learnt that my opponents now fall back upon a new real or supposed distinction between Calamites and Calamodendron, which latter name they apply to the type found at Autun, of which I have not seen a specimen. My friend Graf von Solms tells me that though these Autun specimens have a vascular zone much like that of our English Calamites, our French friends profess to have found in it some peculiar feature which distinguishes Calamodendron from Calamites. This is altogether a new idea, something different from that idea which I have rejected from the beginning. I have opposed Brongniart's views, which have been also the views of the French Botanists during the last twenty years, but of this new idea I have only heard within the last few weeks. It involves a complete change of front. The supposed new feature is one of which we have previously heard nothing, and of which no trace exists among our British Calamites. I have written to one of my friends in Paris to obtain for me, at any price, one of these true Calamodendra in order that I may examine for myself the value of this new character on which my French friends now rely, and until I have done so I will express no opinion about it; therefore, still believing that Calamites have no exogenously developed zone, our French friends now recognise our English forms which have such a zone by the name of Arthropitus. The old dispute thus reappears under a new name, because they regard Arthropitus as being not only distinct from Calamites but as being a Gymnosperm. So that Calamites *versus* Arthropitus now replaces Calamites *versus* Calamodendron. I reject this new separation as earnestly as I did the old one, being convinced that there are no facts which can justify it. And whilst I reserve my judgment about the characteristics of the Autun specimens I am not without suspicion that they will prove to be of

little importance in relation to the botanical position of these plants. As to the special difficulties to which our attention has been called to-day they are all readily explained. Professor Williamson then described in detail some features of the internal structure of the Calamite, using the black board for the purpose of illustration. He referred to the apparent adhesion of large and thick branches to large stems by means of a very narrow conical point. He denied that, when the plants were living, they ever did so. Even in a young state, each of such examples had, surrounding its large fistular medulla, a zone of wood enclosed within a second zone of bark, the magnitude and strength of neither the one nor the other of which is in any way represented by the thin layer of coal which now invests the casts of the medulla in such common specimens. He has in his cabinet specimens which demonstrate the truth of this statement. Some people were troubled to know how it was that, after the woody zone disappeared, the bark should rest so closely upon the sandstone cast of the central cavity of the pith. The bark did not so rest because the thin coaly film referred to does not represent the bark alone. It is a small residuum of all the carbonaceous elements of the original plant to which all the parts of the plant may have contributed, and it is but an extremely small portion of those elements that have recombined in the form of a structureless film of coal. Then as to the longitudinal ridges and furrows, and the succession of transverse constrictions seen in these sandstone casts, and which were supposed to have been characteristic of the outer surface of the bark of the Calamite. The bark exhibited no such ridges, furrows, or transverse constrictions. His cabinet now contains a large number of specimens in which the bark of the Calamite is preserved, in the most beautiful condition, with every cell in its normal state. No one of these barks exhibits the smallest trace of ridges or furrows of any

kind. There was no sort of grooving whatever on the outer surface of any of them. He challenged his friends in France to produce one solitary Calamite which would not prove, on examination, to be Brongniart's so-called Calamodendron. They avowedly had not yet found one of what alone they recognised as Cryptogamic Calamites in which any structure was preserved. Why was this so? Equisetiform plants were preserved in the newer rocks, but when so preserved in the older rocks they all proved to be Brongniartian Calamodendra. The so-called Asterophyllites were generally supposed to be something distinct from the Calamite; but it had been found during the last twenty years, that many of these so-called Asterophyllites differed materially from one another. Some, no doubt, were really the leaves of Calamites, some were leaves belonging to plants having an altogether different structure, though having certain general affinities with the Calamites; but these and many other forms, more or less allied to the modern group of Equisetum, are now very appropriately comprehended in the large family of the Calamitinæ. But many difficulties had yet to be overcome before we should correctly understand the true relationship between the various plants of the coal measures which possessed their verticillate-leaves. He (Professor Williamson) remained as certain as he was of his own existence that the Calamite and Calamodendron, as defined by A. Brongniart, were one and the same thing—there was no difference whatever between them. As to the newly-defined Calamodendron, he would tell them more when he had examined the specimen for himself.

Professor Boyd Dawkins, who was to have read a paper on "The Formation of Agates," suggested that owing to the lateness of the hour this should be postponed till a future meeting. The suggestion was agreed to.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIX. VOL. XVIII. SESSION 1885-6.

WIGAN MEETING.

At the ORDINARY MEETING of the Members of the Society, held on Friday, May 7th, 1886, in the Mining School Buildings, Wigan;

WILLIAM H. JOHNSON, ESQ., M.E.,

In the Chair.

ELECTRIC LIGHTING.

The SECRETARY read the following letter:—

Duffield, near Derby, May 4th, 1886.

Dear Sir,

I beg to draw the attention of the Society at their Wigan meeting to the following extract from the *Nottingham Daily Guardian* of yesterday:—

"The festivities at Clumber were on Saturday morning "in great danger of being prematurely terminated by fire. "About three o'clock in the morning, while the company "were dancing the 'Mother Hubbard Polka,' the hangings "of the north-east corner of the ball-room suddenly caught "fire. The flames were seen by an attendant standing near,

"who seized the ignited portion of the hanging and the "nearest incandescent electric light and succeeded in destroying the lamp and extinguishing the flames. So quickly "was the outbreak subdued that only, comparatively, a few "persons saw the flames, and the piece of material consumed "was only the size of a small plate. The fire is said to "have been caused by the breaking of the glass covering "over one of the electric incandescent lights."

Yours very truly,

G. C. GREENWELL.

Jos. S. Martin, Esq., F.G.S.

NOTES ON THE FRACTURE OF SAFETY LAMP GLASSES THROUGH VARYING TEMPERATURES AND OTHER CAUSES.

By HENRY HALL, H.M. Inspector of Mines.

During the last four or five years more thought and labour appear to have been brought to bear on the subject of safety lamps than on any other branch of mining. We have had elaborate tests by individuals, by mining institutes, and still more important experiments by the Commission on Accidents in Mines.

The result of all this labour has been to prove, among other things, that certain principles must be observed in the construction of all safety lamps to ensure maximum safety, the more important of these being, 1st, the limited admission of air and at a low velocity, so as to avoid danger in currents of explosive atmosphere travelling at high speeds; 2nd, the admission of the air-feed at a point above the burner to ensure the lamp being extinguished on any internal explosion taking place; 3rd, the reduction of the cubical space within the lamp, as far as possible, so that only small amounts of explosive mixtures may be ignited at one time, and thus to limit the mechanical effect of interna

explosions, and also that there should always be a ready exit by means of gauze openings so as to avoid shock from these internal explosions.

The writer believes that in this and other directions much very valuable information has been obtained, and that we might almost hope to be now fully acquainted with the peculiarities of the different types of lamps, their advantages in the direction of safety and their elements of danger, but the experiments referred to have not included, to any large extent, the behaviour of the different lamps when subjected to the somewhat rough work of actual underground mining operations.

The question of how a particular class of lamps may bear the wear and tear of daily use is a most important one, and however theoretically safe such a lamp may be, any serious failure in the above respect must be fatal to its general introduction.

Up to within the last few years, mine officials have been in the habit of looking somewhat askance at the introduction of what are termed glass lamps into fiery collieries. This feeling arises no doubt from the fact that glass is a substance which does not impress one with its strength or reliability. We often hear the expression "as brittle as glass," and we know that there is always a danger of glass flying or fracturing where it is subjected to conditions such as rapid expansion by heat or contraction through cold.

In order to test whether there is any serious danger in the use of safety lamps in the construction of which glass is largely used, the following statistics have been collected :—

No. 1 Colliery sent into the workings 24,334 Mueseler's lamps with Smethurst Shields between February 1st and March 28th inclusive, with glasses in perfect order, and during that period 88 glasses had to be taken out and replaced, 40 of which were either completely broken or in a condition to render it unsafe to continue their use, the

remaining 48 were snipped partly across the edge, but not so as to render them actually unsafe.

Thus it would appear that the average life of a glass at the Colliery referred to is about 276 working days, or assuming 600 lamps to be sent down each day, then 2·10 glasses would require renewing daily, but only about one per day would be found actually dangerous in a total of 600 lamps.

No. 2 Colliery sends into the workings 590 Mueseler lamps (without shields) per day, and during one week of six days they changed 11 glasses, which were actually dangerous, during this period glasses were passed unless broken or snipped right across the edge.

At the same mine, for four succeeding weeks, the average weekly number of glasses renewed was 21 per week inclusive of glasses snipped only partly across the edge, thus there was 3·50 glasses renewed daily, but only a little over one lamp per day was found actually dangerous in a total of 590.

No. 3 Colliery sent down 367 Mueseler lamps (without shields) daily, and changed 32 glasses per week of six days, or 5·33 glasses per day, of which nearly 2 per day were found actually dangerous, in a total of 367 lamps.

No. 4 Colliery sent down 310 Mueseler lamps per day (without shields), and changed 34 glasses per week of six days, or 5·66 per day, of which about 1·50 per day were found actually dangerous, in a total of 310 lamps.

No. 5 Colliery sent down 212 Mueseler lamps (with shields) per day, of which 0·33, or one lamp glass in three days was actually broken, but in this case no notice appears to have been taken of glasses snipped on the edge, and the breakages are stated to have occurred in transit to be relighted.

No. 6 Colliery gives the number of Mueseler lamps in daily use during last year as 129, and the number of glasses

changed as 49 in all, making the life of a glass about two and a half years.

These statistics, although far from complete or conclusive, appear to make it sufficiently clear that this question of the fracture of lamp glasses is an important one, and one which requires more light to be thrown upon it; and it will be well worth the while of those managers who use glass lamps largely to furnish the Society with reliable statistics covering a lengthened period, and making a distinction between fractures such as are actually unsafe and those which are only partially so. At present, and pending further inquiry, we may assume the life of a glass to be something less than a working year, and that in a mine working 500 lamps, at least one lamp each day will be found to have been rendered actually unsafe either from fracture by a blow or through the glass flying by contraction or expansion, on account of varying temperature, and although this may not at first sight appear to be a very serious matter, yet when we bear in mind that where a fracture occurs through changing temperature there is little chance of its being discovered till the end of the day, when the lamp is taken to pieces in the lamp cabin, all must feel that there is a danger which, if possible, should be remedied. The writer believes that where Gauze lamps are in use in well-disciplined mines that the number of such lamps rendered actually unsafe underground is very small as compared with glass lamps.

The principal cause of glasses snipping on the edge appears to be too tight screwing into position, and this is more especially the case if the glass itself is not of exactly the same height over its whole circumference. Another cause is imperfect annealing. The writer believes that the proper annealing of the glasses can be tested by an instrument called a polariscope, and that in all cases washers of asbestos to pack the glasses should be used.

A series of experiments have been carried out to test,

artificially, the effect of varying temperature on glass lamps. With this object, 12 lamps, screwed loosely, were placed in a somewhat close box heated by gas up to 120° and left for 1½ hours, and then the glasses were carefully examined and found unaffected in any way. Twenty lamps, tightly screwed, were then inserted and the temperature raised to 150° and left for 1 hour; on examination, in two cases very slight signs of snipping were visible, but to a very unimportant extent. The apparatus did not admit of the temperature being changed rapidly, and on this account the experiments were inconclusive. It is hoped that they may be carried further.

The glasses were readily fractured, in their hot condition, by casting a little cold water on them, such as might occur in a wet working.

The CHAIRMAN said it was a very important subject and well worthy of the attention of those interested in collieries. At Mr. Hall's request he had obtained a few particulars for him, but only extending over a limited period, so that he was rather doubtful as to whether they would be sufficiently reliable. But since then he had found that they might expect that about two and a half glasses per thousand lamps sent down would have to be renewed. That percentage included glasses broken, as well as those just snipped on the outside and not rendered unsafe. He might add that he would be very glad at any time to give any particulars he could for the benefit of the Society, and he was having a record kept of glasses sent down and broken or snipped.

Mr. BURROWS did not quite agree with Mr. Hall's conclusions. Some of the breakages referred to by the author of the paper would be produced by a blow, but the same blow would have severely damaged the gauze of an ordinary safety lamp. At the colliery with which he (Mr. Burrows) was connected the breakage of glasses was exceedingly rare,

but he intended to have a record kept of all glasses that got snipped or broken. Of course it was no use having a lamp that would not stand a great velocity in the air; and his opinion was that the lamps with glasses had come out well in the tests to which they had been subjected.

Mr. PEACE said it was always a point with him to get the best possible glass he could secure. He did not know the percentage of broken glasses at his colliery, but for the last year or two the number had been small. He also would be glad to assist Mr. Hall by having a record kept, and furnishing him with the result.

Mr. HEDLEY asked if the figures quoted by Mr. Hall applied only to glasses. Nothing had been said about the gauze of the lamps.

Mr. MARTIN said he had no doubt that Mr. Hall's suggestion would be carried out, and that a record would be carefully kept of the accidents to safety lamp glasses. The matter would thus be brought more pointedly under the notice of the managers of collieries, who would then perhaps be enabled to adopt measures which would lessen the number of such breakages, and reduce the percentage below that which Mr. Hall had given. At the same time it should not be forgotten that many of the glass lamps were with safety subjected to higher velocities than the ordinary Davy, or gauze lamp, and that they give a better light, and consequently additional safety from a very serious source of danger, namely, falls of roof and sides. The latter quality is a very important one in view of the controversy respecting the use of naked lights *versus* safety lamps.

Mr. MCKINLESS enquired if the glasses broken were of British or foreign make. A large quantity of foreign-made glass had been introduced to this country in recent years because of its cheapness. He understood that certain kinds of glass could be imported from Bohemia and sold for less money than British-made glasses, and he suspected that this

circumstance had something to do with the number of breakages. The snipping in the glass was certainly a source of great danger, but he thought if the glass were properly made, properly annealed, and of British metal, it would stand a very great amount of wear and tear, and answer the purposes of a lamp as well, if not better than gauze.

Mr. A. H. LEACH asked if the breakages occurred at the working faces.

Mr. MARTIN said that having had experience with glasses of foreign and of British make he found that if good qualities of each were compared there is very little difference between them, but that if a good quality of the one is compared with a poor quality of the other, results can be obtained to suit the particular wishes of the experimenter.

Mr. HALL, in reply, said that his figures applied only to glasses and not to the gauzes. As to the nationality of the glasses that had been broken, he could not say whether they were English or foreign, but he thought a good many of them were supplied by a Manchester firm. As to whether the glasses were damaged at the face of the workings or not, he had to say that in some cases they were damaged at the face of the workings and in others on the roads. His intention in writing the paper had not been to set up any comparison between different lamps. For his own part he was quite satisfied that many of the glass lamps were very much superior to, and safer than, the ordinary Davy lamp, but he took what seemed to be the weak point in the glass lamp, and his object was to see if by collecting statistics from the different collieries they could not find out the amount of the danger, and then set to work to find out the remedy.

Mr. HEDLEY observed that the snipping seemed in most cases to be attributable to a defect in the manufacture. If he was right in that view it was a matter for the manufacturers and the colliery managers to deal with.

NOTES ON BROWN'S SAFETY CATCH FOR WIRE ROPE GUIDES.

By C. F. Clarke, M.E.

The Secretary, in the absence of the writer, read the paper:—

The mining community of this country are much indebted to the reliable aid that has ever been most readily accorded them by the mechanical genius of her engineers and inventors. We owe many of our greatest improvements to them, and mining engineers have ever been ready to acknowledge the services thus rendered and always willing to lend assistance in developing and perfecting any appliance having for its object the saving of life or labour in and about our mines.

We are apt to view many of the patents and inventions that are constantly being brought under our notice with a good deal of scepticsm, but when once we are satisfied of the value and efficiency of any particular appliance we readily adopt it.

The legislature has wisely left us free to avail ourselves of any improvements and inventions that may be deemed worthy of adoption, and as long as this is the case we may continue to expect further developments in such matters.

The Safety Catch invented by Messrs. Brown, of Little Hulton, was brought to my notice some months ago, and after several interviews, I arranged for them to attach them to one of our cages.

The cage is a single deck, carrying three boxes in a shaft 420 yards deep, working on three conducting wire guides $1\frac{1}{8}$ inch diameter, firmly fixed to cross-bars on the head gear. Two on the inside angles of the cage and one on the outside in the centre of the cage. The guides consist of seven strong wires, three-eighths diameter.

The weight of cages and chains is	27	cwts.
Do. three loaded boxes. .	33	,,
Total weight of loaded cage. .	60	cwts.

There have been three or four experiments made to test the invention by means of a knock-off hook, both with the empty cage and with it loaded, and on all occasions the apparatus acted instantly, the cage not dropping more than six inches when loaded.

The cage has been at work about five months, and during that time we have had no hitch or trouble with it.

In adopting the catches, care should be taken to see that the guides rods are of sufficient strength to carry the full load of the cage, and that they are securely attached to the head gear.

I will now give you in Mr. Brown's own language his description of the appliance.

"This invention has for its object the prevention of "accidents from the breakage of the rope, band, or chain by "which the cage, or other such arrangement, is held or sus- "pended, and consists in an arrangement of apparatus for "arresting or stopping the descent of the cage employed "in mines and other shafts which are provided with round "wire guide-rods extending from the top to the bottom of "the shaft.

"On each side of the cage levers are situated; these "levers turn upon pins firmly secured to the sides of the cage, "and which form the centres or bearings for such levers to "work upon. The ends of the levers nearest the iron or "wire guide-rods are provided with hinge joints, from "which extends upwards, or otherwise, suitable rods having "rollers or bowls concaved to the circumference of the "guide-rods with the sides extending sideways, having flat "circular surfaces in order to ensure a more perfect and "effectual grip or hold on the guide-rods and inclined

"planes, the latter being suitably fixed to the sides of the "cage. The opposite ends of the levers are each secured by "a hinge joint to connecting rods or other equivalents which "are united or joined together above the cage to the stride "chains or winding rope. When the cage is suspended, the "rollers or bowls are drawn away from the guide-rods and "the inclined planes; the whole weight of the cage and its "contents being supported by its own tie-rods or chains, "which form the connection between the cage and the rope, "but in the event of the rope or any of the connections "breaking, the apparatus comes into operation by the "suspended ends of the levers falling and consequently the "opposite ends rise, with the rollers or bowls, into the "inclined planes and grips the guide-rods, whereby the "cage is held or supported by its own weight acting upon "the rollers or bowls in the inclined planes, thus pre-"venting its falling or descending the shaft.

"To ensure the levers operating quickly, springs are em-"ployed for pressing on the levers so as to force them "against the guide-rods immediately upon the breakage of "the rope or chains."

Mr. BROWN, the inventor, in replying to the enquiries, stated that on one occasion at the pit referred to in the paper, the cage had been suspended in the shaft, owing to one of the chains, temporarily attached in the trials, having broken.

Under its action a cage was sure to stop when the rope broke. He had tried it in the presence of, and by the permission of, Mr. J. S. Burrows, with a weight of five tons which dropped a distance of seven feet on to the top of a cage, and the catch stood the strain.

Mr. HALL remarked that if a number of men were in a cage which was going at the rate of, say 30 or 40 miles an hour and the rope broke, and the cage were pulled up instantly there would be a fatal result. The answer of the

of the inventor to such an observation as that would no doubt be, that men should not be wound up at such a speed. The invention was useful if it prevented only some of the accidents which arose from ropes breaking, and on that account the inventor was, he thought, very much to be commended for having brought the subject before the Society.

Mr. MARTIN said that he had seen through the kindness of Mr. Clark, several trials with the catches at Park Lane Colliery, they came into operation effectively with a load of 59 cwt., and to his mind the question was not the efficiency of the catch so much as the result upon the conducting ropes when the weight would be thrown suddenly upon them. In the trial in question the ropes were squeezed from 1⅛in. diamater to ¾in. by 1 1/16in., and ⅞in. by 1¼in. The use of such safety arrangements when men are raised and lowered is certainly desirable if not liable to get out of order, and thus create a danger themselves. He had not heard of the Owen's Patent Catch for Wooden Conductors getting out of order, or causing trouble in working, although probably there are more in use in the Manchester district than in any other part of the kingdom. Owen's Catches have on many occasions acted efficiently, and did so at Clifton Hall Colliery on the occasion of the explosion, having been brought into operation by the upward pressure causing slack rope.

Mr. HALL said that he had an impression the catch sometime came into partial operation when not intended.

Mr. BROWN submitted that the catch was not at fault when that occurred.

Mr. MARTIN stated that in Prussia, 14 years ago, the want of such an arrangement was one of the difficulties in regard to the introduction of wire rope guides, as they were precluded from bringing up men in cages without a safety catch being employed. They had not got efficient catches then, but he believed there had been some introduced since.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XX. VOL. XVIII. SESSION 1885-6.

The ORDINARY MEETING of the Members of the Society was held on Tuesday, June 1st, 1886, in the Literary and Philosophical Society's Rooms, George Street; Manchester;

The President, H. M. ORMEROD, Esq., F.G.S.,

In the Chair.

The following are the recent additions to the Library:—

Chesterfield and Derbyshire Institute of Mining Engineers: Transactions, Part 5, Vol. XII., Part 6, Vol. XIV., Part 1, Vol. XV.—*From the Institute.*

Cornwall, Mining Association and Institute of Cornwall: Transactions, Part 2, Vol. I.—*From the Institute.*

Devon and Exeter Albert Memorial Museum: Sixteenth Annual Report of Committee, 1886.

Dublin, Royal Dublin Society: Scientific Proceedings, Parts 7-9, Vol. IV., Parts 1-2, Vol. V.; Scientific Transactions, Parts 7-10, Vol. III.—*From the Society.*

Glasgow, Natural History Society of: Index to Proceedings, Vols. 1-5; Proceedings and Transactions, Part 11, Vol. I., 1884-5.—*From the Society.*

Hertfordshire Natural History Society and Field Club: Transactions, Parts 8-9, Vol. 3.—*From the Society.*

Leeds Philosophical and Literary Society: Annual Report 1885-6.

Liverpool Geological Association: Transactions, Vol. V., 1884-5.—*From the Association.*

London, Royal Society: Proceedings, No. 242, Vol. XL.—*From the Society.*

Ditto, Geological Society: Quarterly Journal, No. 166, No. XLII.—*From the Society.*

Ditto, Geologists' Association: Proceedings, No. 5, Vol. IX.—*From the Association.*

Ditto, Geological Magazine: Nos. 262-4.—*Purchased.*

Ditto, Institution of Mechanical Engineers: Proceedings, No. 1, February, 1886.—*From the Institution.*

Midland Institute of Mining Engineers: Transactions, Part 81, Vol. X. —*From the Institute.*

North of England Institute of Mining and Mechanical Engineers: Transactions, Part 11, Vol. XXXV.—*From the Institute.*

Scotland, Mining Institute of Scotland: Transactions, Part 9, Vol. VII. —*From the Institute.*

Radcliffe Library, Oxford University: Catalogue of Books, 1885.

Accidents in Mines: Final Report, 1886.—*From Her Majesty's Commissioners.*

Ninth, Tenth, and Eleventh Reports of Committee, Circulation of Underground Waters.—*From C. E. de Rance.*

Dr. Ure's Dictionary of Arts, Manufactures, and Mines. 4 Vols.—*Purchased.*

Earthquakes of Ischia. By H. J. Johnston-Lavis.—*Purchased.*

Accidents in Mines in the North Staffordshire Coalfield. By A. R. Sawyer.—*Purchased.*

Canada: Contributions to Canadian Palæontology, Part 1, Report on Invertebrata of Laramie and Cretaceous Rocks. By J. F. Whiteaves, F.G.S.—*From Director of Survey.*

Summary Report of Geological and Natural History Survey of Canada to 31st December, 1885.—*From Director of Survey.*

U.S.A., Harvard College, Cambridge: Bulletin of Museum of Comparative Zoology, Nos. 3-4, Vol. XII.—*From A. Agassiz.*

New York: Annual Report of Trustees of American Museum of Natural History, 1885-6.

Philadelphia, Academy of Natural Sciences of: Proceedings, Part 3, August-December, 1885.—*From the Academy.*

Philadelphia: Journal of Franklin Institute, Nos. 724-726.—*From Institute.*

Washington: Bulletin of U.S. Geological Survey, Nos. 15-23.—*From Director of Survey.*

Victoria, Gold Fields of: Reports of Mining Registrars; Quarter ending December 31st, 1885.

Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft, Heft 4, Band XXXVII., Heft 1, Band XXXVIII.—*From the Society.*

Brussels: Société Malacologique de Belgique, Procès-Verbal, August 1-December 5, 1885.—*From the Society.*

Buenos Ayres: Censo Escolar Nacional, 1883-84, Tome XI. Two copies. —*From the Government.*

Christiania: Royal University of Norway: Lakis Kratere og Lavastromme, by Amund Helland.—*From the University.*

Dresden: Sitzungsberichte der Isis in Dresden, 1885.—*From the Society.*

Leipzig: Systematische Übersicht der fossilen Myriopoden, Arachnoideen und Insekten, by S. H. Scudder.

Lille: Société Géologique du Nord, Annales 12, 1884-5.—*From the Society.*

Paris: Revue de la Législation des Mines, Mars-Avril, 1886.—*Purchased.*

Pisa: Atti della Società Toscana di Scienze Naturali: Memorie, Vol. VII. —*From the Society.*

Roma: Atti della Reale Accademia dei Lincei: Rendiconti 7-11, Vol. XI.—*From the Academy.*

St. Petersburg: Academie Impériale des Sciences. Mémoire, No. 5, Tome XXXIII.—*From the Academy.*

Wien: Annalen des K.K. Naturhistorischen Hof Museums, No. 2, Band I.

NEW SAFETY LAMP.

By M. Mercier, M.E.

Mr. M. Mercier exhibited and explained a new safety lamp designed principally for the use of firemen, shot-lighters, and other officials in mines. He thought that, in the event of the electric light being adopted, as it very probably would be in 10 or 15 years, colliery managers would still need, in addition to a gas indicator, a lamp for their officials which could be used either for firing shots or testing for gas. Some people preferred the Mueseler lamp for gas testing, but, whilst he would have no hesitation himself in using a Mueseler, he thought it would take a long time to educate firemen to examine places with a Mueseler type of lamp so that they would exercise due care to prevent the lamp being extinguished. If they

got into gas with any type of extinguishing lamp, the fear of losing their light might be an inducement to some to shirk a proper examination. When a fireman was down a pit he had a long distance to travel, and if he got without a light it was probable that the working of that district would be delayed several hours, if not stopped for the entire day. In constructing his lamp he (Mr. Mercier) felt that, although glass gave them a very much better light than gauze, yet it was not an adequate protection to the flame of a safety lamp. He had known a Bonnetted Mueseler (which would stand almost as severe a test as any lamp, and was one that the Commissioners had recommended), after being examined and reported safe, put into the lamp tester, with the result that it immediately lit the gas. This was owing to some imperfection in the glass or rings which the fireman had not been able to detect; and he thought that glass by itself was too frail a substance to place in the hands of ordinary pitmen. Although, as he had said, the lamp now exhibited was mainly for the use of officials, it still might be used by colliers with a fixed instead of a movable glass. Mr. Mercier described the lamp as follows:—

MERCIER'S COMBINATION OF JACK AND IMPROVED MUESELER.

This lamp consists of an upper and lower gauze connected together by two stamped brass rings with flanges. Inside there is placed a chimney with a small vertical gauze (in lieu of the horizontal gauze on a Mueseler chimney) which rests on the seating formed by the lower gauze ring, and is held in position and a tight joint made by the flange of the upper brass ring. The gauzes are surrounded by two shields and a glass (fixed for the use of colliers), which slides up between the shields. The outer shield is a fixture, and its purpose is to protect the inlet holes of the inner shields when in high velocities, and also to be a cool medium by which to hold the lamp. The inner shield is also a fixture,

and has a row of holes for the admission of air above the glass. The outlet holes at the top of the lamp are only large enough to allow the escape of the products of combustion of the wick flame, and are protected also by a ring or shield. The glass fits closely against the flanges of the brass rings, and makes a good joint at the top. At the bottom the glass rests in a grove formed by the screw ring having a rim projecting upwards into the glass, and as it only screws a portion of the depth of the lamp collar, it is protected on the outside by a rim of metal, and so makes a tight joint. To protect the edges of the glass from getting chipped there is a tight fitting brass ring on the glass. The gauzes are fastened to the rings, and so prevent the danger of the gauzes stretching and making a loose or imperfect joint. There is also a smoke cap on the chimney to protect the gauzes from getting burnt at the crown, where there is a double thickness of gauze. All the four loose parts of this lamp are put together before screwing into the lamp framing.

Mercier's Extinguishing Lock.

This lock which can be applied to any form of lamp, consists of three parts—namely, two levers and a bolt, one lever having an extinguishing cap affixed. The lamp is locked by pushing a bolt with a tooth at the inner end into the lamp's lower ring from the outside. One of the levers carries a tooth which fits, being the reverse way up, the tooth on the bolt. To unscrew the oil vessel the bolt must be withdrawn when it draws back the toothed lever, which by actuating the extinguishing lever the cap is brought over the flame and the light extinguished. The lamp can be also locked by a lead rivet or other lock passing through the bolt and a lug on the oil vessel.

The CHAIRMAN asked if Mr. Mercier's lamp was heavier than the Davy?

Mr. MERCIER: It weights 2½lbs.—that is rather heavier than the Davy, but lighter than most lamps.

Mr. BURNETT: Will it burn any kind of oil?

Mr. MERCIER: It is made to burn colza or rape oil, with a flat wick.

Mr. MARTIN said: If I understand the description correctly, the lamp is a Mueseler under ordinary circumstances, but that the gauze comes down to the bottom in the same way as the Davy; in fact it is an application of the Davy and the Mueseler. When the glass is down it acts as a Mueseler, the light going out when it enters gas. The object, as it appears to me, is to enable firemen to go round in the morning with a Mueseler lamp, and upon reaching a place where they want to try for gas they are able to move the glass upwards and then convert the lamp into a Davy for the time being. How far the moving of the glass will cause a disarrangement can only, I suppose, be established by practice; I do not know whether a sufficient number of these lamps are in actual use to decide that point, but judging from the description, this lamp would seem almost to have been made to comply with the terms of the proposed new Mines Regulation Bill. As regards the chipping of the glass I do not think that the ring which Mr. Mercier speaks of would altogether prevent that, because where the chipping or cracking takes place, as the result of overheating, I apprehend it would still occur whether the ring was there or not, and would depend in a great measure on the quality of the glass.

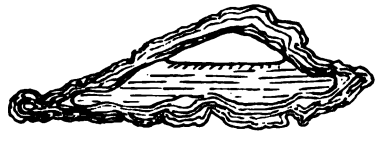
ON THE FORMATION OF AGATES.

By Professor W. Boyd Dawkins, F.R.S.

Professor Dawkins said: My object in bringing this subject before the Society is to ask attention to the very interesting set of specimens now before you, which illustrate the very curious and remarkable formation of agates. If you examine an agate you will see that it is built up of a series of layers, generally concentric, which are variously coloured, and which, when examined microscopically, are found to be of different textures. The history of agate formation may be summed up very briefly in this fashion. Supposing you take this black-board to represent a mass of rock with cavities in it; water, percolating through the rock, and charged with the material which now assumes the structure of agate—that is to say, silica—has found its way into these cavities, and as a result we have in the first instance a layer of silica lining the cavity. As a rule you will find not merely one layer, of one homogeneous material, but a series of layers of different compactness, and you may have them repeated over and over again until at last the whole of the cavity is filled with the agate substance—silica, in the condition of chalcedony and quartz. In this manner the banded structure is produced. The specimens on the table illustrate that fact. In one of these specimens you will see that the interior is hollow. That is a specimen of an agate which is imperfectly formed. You can see how the layers of crystals—which in this case consist of amethystine quartz—have their points directed inwards. The hollow is not completely filled, and you have not a solid mass as in other specimens.

Now let me call your attention to another specimen

kindly given to me by Mr. Parlane. It consists of chalcedony, and contains within its interior some of the water from which the deposit forming the chalcedony was obtained. Moreover the water does not fill the hollow, and there is a clearly defined bubble. It represents to us an agate in process of formation (*see figure*). Its history, to my mind, is somewhat as follows:—It has occupied a cavity in the rock, but the rock has been denuded away before the hollow had been completely filled up with chalcedony, and as a result we have the water in which the silica was originally dissolved still preserved in the interior. The specimen came from Uruguay, in South America.



In a second specimen picked up on the Lancashire coast, near Rossall, the process is completed, and you have a solid mass of silica instead of a hollow containing water. All agates are formed, in this way, by a series of depositions beginning on the outside and extending into the interior. They are the result of an action for which I have adopted the term incretionary, because their formation is from the outside to the inside, rather than concretionary, where there is the opposite course of formation. In an ordinary ironstone nodule the innermost layers are formed first, and the outer ones last. This is the simple explanation of the formation of agates. This process goes on not merely in hollows, such as you see there, but sometimes also in veins.

Now comes a point which to my mind is of interest in relation to the colouring of agates. In one of the specimens exhibited, the interior is of a bright red colour. That colour is due to the peroxide of iron which has infiltrated into

the substance of the stone. But there is great variation in the colours. Here, for instance, is a natural agate, in which the general mass of the stone is a dark brown; but there are clear white lines, indicating the hard and compact portions of the stone into which no infiltrating material could find its way, and where, consequently, you have the silica in its pristine whiteness, unconnected with any colouring matter. Of course, as you know, there is in the rocks a good deal of colouring matter, in which iron predominates. Consequently you have many agates coloured red. There is also much manganese; and a combination of this and the oxide of iron causes the black colour which is noticeable in some of the layers.

We must now consider colours produced artificially. The artificial colouring of agates is a comparatively easy process, and one which has been known for a very long time. Even as early as the days of Pliny the Greeks were in the habit of soaking agates in honey and water; then they baked them in a furnace, and wherever the honey could find its way into the loose porous texture of the agate, there the heat followed and carbonised it, converting the porous layers into more or less darkly tinted bands. The onyx is merely an agate which has been subjected to this artificial process. The white layer in the onyx is the layer into which the infiltrating material could not get, while the dark layer is represented by the carbonised particles of honey which have been burnt in the pores of the stone. It is mainly a question of contrast; and the various shades from blackness, through brown, merely mark the degree of porosity of the stone, the most porous layers taking most of the carbon, and therefore being blackest, while the more compact layers are not so black, and pass through every shade of brown. The white ones are those which are too compact to allow of the introduction of carbon.

The trade in agates and onyxes is carried on in all places of fashionable resort all over the world. Supposing, for instance, you were to go to Aberystwith, you would probably find time hanging rather heavily on your hands, and would go down to the shore to look for pebbles. You would gather a basket-full perhaps, and take them to a lapidary in the town. The lapidary would promise to try to find an onyx, or something of the kind, in your basket, and would ask you to call again in a few days. You would, of course call again, and then he would sell you an onyx brooch, or a seal, or other article which you would think very pretty, and which would be valued highly because you found it yourself. You go away thinking that you are a most fortunate person to have found such beautiful stones. Moreover, as a rule, you feel very much annoyed that the lapidary has kept the pieces, and will not give them up, however much you may press him. As a matter of fact, no natural onyxes are found at Aberystwith or anywhere else on the British shores.

All the onyxes, or nearly all, which are so widely spread over the world are manufactured in the Eifel, and mostly at a place called Oberstein, and they are manufactured practically in the same way as they were by the ancient Greeks but with this difference. When sulphuric acid became known it occurred to the modern manufacturers of onyxes that a much better process than baking would be to immerse the stones saturated with honey and water in sulphuric acid, and let the acid catch up the particles of carbon in the pores of the stone. This is the only difference between the ancient and the modern methods. The trade is a very old one in the Eifel, and it rapidly exhausted the supply of agates. For some time there was a doubt whether there would be any more agates to make into onyxes, but it happened about 30 years ago that some workmen who had migrated

from the Eifel to South America discovered magnificent agates. From that day to this, Oberstein has derived its chief supply from Brazil. At Oberstein the stones are stained, cut, polished, and formed into beautiful things which are so familiar to everybody, and which are handed to you by the lapidaries in place of the stones which you brought to them.

Nor are the stones lost which have been so industriously collected and taken to the lapidary in the course of the season. Professor (now Sir Andrew), Ramsay once happened to be in Aberystwith in the winter time, and he lodged opposite to the place of business of one of the lapidaries. To his delight one morning he saw the stones which had been accumulated during the previous season in the back yard being carted away to the shore, there to be picked up by a fresh generation of tourists. They circulate continually from the shore to the shop, and from the back yard down to the shore.

These facts may, perhaps, possess a certain amount of interest and curiosity for those who have not thought much about agates and onyxes. I, for one, till I made out this history, was under the impression that they were widely distributed in a state of nature. But they are not. I doubt if a natural onyx has ever been found in this country, and I do not know that the very oldest Greek and Roman onyxes are not artificially coloured.

The PRESIDENT: I have large specimens of onyxes, weighing about 1lb. cut across. These are called Brazilian, not pretended to have been picked up in England. I suppose those will be in their natural state?

Professor DAWKINS: I should think those have probably been to Oberstein to be coloured and cut.

The PRESIDENT: Are we to class the moss agates among the other manufactured articles?

Professor DAWKINS: The moss agate is natural, and is mainly a dendritic formation in a quartz vein. They are found on our coasts. Most, however, of those in the shops have been obtained from the great stone-cutting region of Oberstein, where they are sometimes coloured bright green and blue, with various metallic salts.

In answer to a question by Mr. Burnett.

Professor DAWKINS said: That all along our coast there were to be found small agates and cornelians. They were very widely spread, and it was probable that they were deposited with the boulder drift. He did not know that they had ever been found *in sitû* in any part of the United Kingdom except Wales and Scotland.

ELECTRIC LIGHTING IN MINES.

DISCUSSION ON MR. CONNOLLY'S PAPER.

(Transactions Part XVII., page 479.)

Mr. MARTIN said: Mr. Connolly promised when he was last here, to try and obtain further information, and also, if possible, exhibit one of Mr. Swan's new lamps. The members will no doubt be pleased to hear any supplementary remarks he may have to offer. At the last meeting, at Wigan, he read a letter from Mr. Greenwell, in which attention was drawn to a paragraph in one of the Nottingham papers, where it was stated, that during certain festivities in that neighbourhood, some window hangings were observed in flames, the fire having been caused, it is thought, by the incandescent electric lamp. The discovery having been made in good time a lamentable disaster was averted. One could hardly imagine, if such was the case,

that in the event of an incandescent lamp getting fractured it would be quite safe in an explosive atmosphere.

Mr. CONNOLLY said he did not know that he had anything to add to what he said at the former meeting upon this subject. He regretted, however, that the attention of the Society, at the Wigan meeting, should have been drawn to a statement so devoid of truth as that which had appeared in the Nottingham paper. The very life of an incandescent lamp consisted in the maintenance within the glass bulb of a perfect vacuum. The carbon filament from which the light was derived, could only exist so long as that vacuum was preserved; the moment the lamp was broken the filament ceased to exist. The curtains, therefore, in the case in question could not have been set on fire by the incandescent lamp. With regard to Mr. Swan's new lamp, he had a letter from that gentleman, in which he said that the lamp had not reached the stage of being a perfect safety lamp, and he, therefore, could not send it for exhibition. That was as far as he could go that day; but he hoped there were gentlemen present who had thought the matter out, and would state their views as to the question of whether it was likely the electric light would ever be brought into use in mining.

The PRESIDENT asked if it could not be possible, at the moment of an incandescent lamp being broken, for the incandescent filament to ignite the gas in the event of the accident taking place in an explosive mixture.

Mr. CONNOLLY said he purposely left that question open in his paper. It was open to question whether gases would explode under the conditions stated. He was in hopes that some one would have worked the problem out. But a red hot poker—or one even at a white heat—he believed would not explode gases. The electric spark would decompose gases, but whether it would explode fire-damp was doubtful.

Mr. MARTIN observed that he had frequently seen gas jets ignited by a red hot poker. If gas would thus ignite he would not like to say that an explosive mixture would not be fired by the exposed carbon of an incandescent lamp.

Mr. MERCIER said on Easter Tuesday an electric lamp belonging to a Russian was brought to the Pemberton Colliery. One advantage claimed for it was perfect safety; if the glass got broken in an explosive mixture, it would not, the inventors said, light the gas. This was a point he (Mr. Mercier) had always contested, and he discussed it with the gentlemen who brought the lamp. They agreed that a trial should be made. The apparatus for testing was accordingly prepared, and the lamp introduced into an explosive mixture, with the result that the gas was ignited upon the glass which enclosed the carbon filament being broken. Mr. Swan himself, in a letter to him, said—"Certainly any electric light, if you break the glass, will ignite gas when it is present before the carbon filament can be destroyed."

Mr. MCADOO said that at the pit near Hamilton, referred to by Mr. Connolly in his address, some gentlemen were recently invited to inspect the electric lighting arrangements. There was present, amongst others, Professor Forbes, of the Glasgow University.

A mining engineer, Mr. J. B. Simpson, asked Professor Forbes whether, in his opinion, a spark from the wire would ignite gas in the mine. The answer given by Professor Forbes was: "I should not like to say it." Mr. Simpson doubted the probability of the gas being so fired, and it was agreed that the thing should be put to the test. So they went into one of the strait places, where a little gas was accumulated at the roof, and a wire being led into it an electric spark was given off. The gas was ignited at once. That certainly upset Mr. Connolly's theory that it

was doubtful whether an electric spark would light gas in the same way that a flame would do. In the district to which he understood Mr. Connolly belonged he had seen the banksman take a red hot poker in a morning and go with it in his hand and light the gas up and down the pit brow.

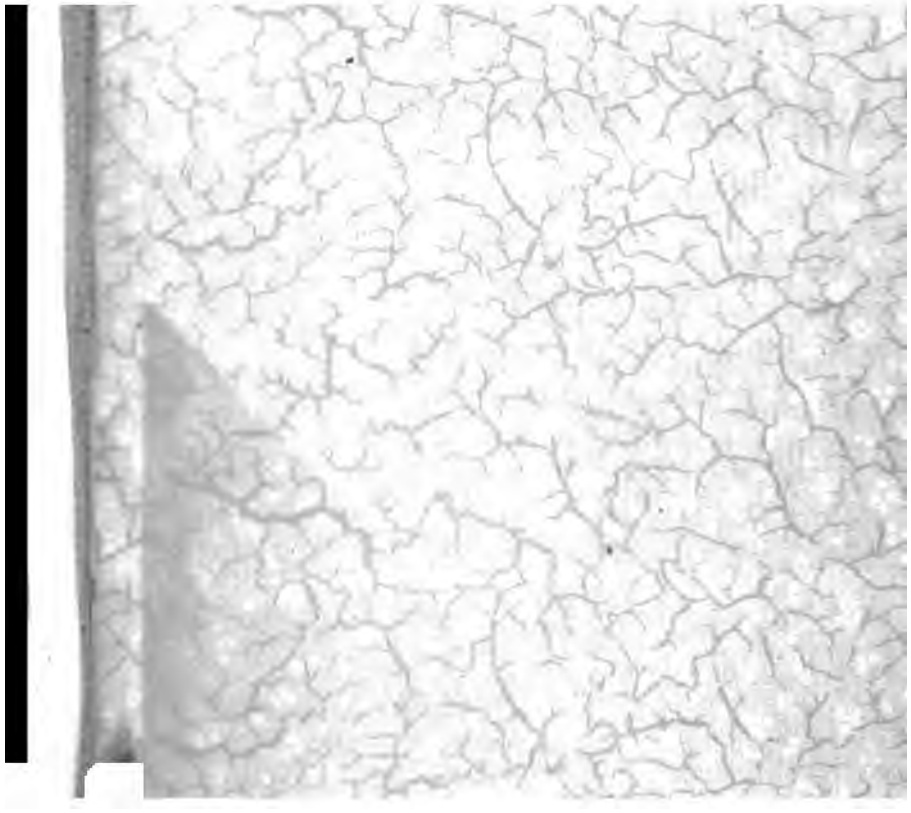
Mr. BURROWS said it was quite true as Mr. Connolly stated that an incandescent lamp went out as soon as the glass was fractured, for as soon as the carbon film caught the oxygen of the air it was consumed. But it must take a fraction of a moment for such consumption to take place, and that was when the mischief would be done. At the same time he did not see how it was possible for an incandescent lamp to have set fire to a curtain. As to gas being lighted by a red hot poker he could bear out what Mr. McAdoo had said.

Mr. CONNOLLY: It would be coal gas that you experimented upon.

Mr. BURROWS said he had just been reminded that in cotton mills the electric spark was now frequently used in lighting gas jets.

This concluded the business of the Session.

END OF VOL. XVIII.



Stanford University Libraries
3 6105 008 195 716

LOCKED STACKS

212964